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lors, held this day between the hours of two and five in the afternoon, reported that the following-named persons had been chosen according to the laws, regulations and ordinances of the Society to the offices for the ensuing year:

President.

Frederick Fraley.

Vice-Presidents.

Coleman Sellers, Isaac J. Wistar, George F. Barker.

Secretaries.

I. Minis Hays, Frederick Prime, Samuel P. Sadtler,
Richard A. Cleemann.

Treasurer.

Horace Jayne.

Curators.

J. Cheston Morris, Benjamin Smith Lyman, Henry Pettit.

Councillors to serve for three years.

George R. Morehouse, Patterson DuBois, Henry C. Trumbull,
C. L. Doolittle.

The Society was adjourned by the presiding officer.

THE DESCENT OF THE PIERIDS.

(Plates I-IV.)

BY A. RADCLIFFE GROTE, A.M.,

Vice-President of the American Association for the Advancement of Science, Etc.

(Read January 5, 1900.)

GENERAL WING CHARACTERS OF THE PIERIDS.

A horde of bright butterflies with entire wings, simply marked in gay and contrasting colors: white, yellow, orange, red, brownish and black, rarely with a blue reflection or a lilac shade, but often marbled beneath with lichen green, of the most general distribution, and numbering almost all of the very few species of diurnals counted as injurious to vegetation. The neuration of the

Pierids may be best compared with that of the Limnadidæ among the brush-footed butterflies, but is most clearly more specialized. The cells are closed, but the transverse vein is often degenerate. There are still, sometimes, very small backward spurs, slight remainders of the vanished base of the median system. The cubital cross-vein has left no mark. The fork to the second anal vein of the fore wings at base is very thin and transparent. The trace of the first anal vein has usually disappeared. The upper median branches ascend the radius, in the specializing movement attending the disintegration of the system of the media. The radial branches are reduced at times to three, the usual number is four, and very rarely the five original branchlets are retained on the primary wing. On the hind wings the humeral cell is reduced, often the central slit can with difficulty be discerned, and sometimes the veins appear to be here completely fused and the subcostal to be single. The humeral spur is usually present, but vanishes in specialization. There are two anal veins on the secondaries. These characters show that the Pierids belong to the second division of the diurnals, in which the free and short downwardly curved third anal vein of the fore wings of the Papilionides is absent, viz., the Hesperiadæ.

An antecedent specialization has taken place on the hind wings in that the radius is single, or, if we adopt the view that it is furcate at base and that the costal cell is formed by R_1 , two branched. Present specialization seems still to favor the secondaries, as in those Nymphalids in which the cell is open on hind wings and closed on primaries, the reverse appears never to happen. But in the Parnassiidæ and the Pierids the progressing disintegration of the median system appears more marked now on the primaries, where the upper branches ascend the radius and the cross-vein weakens.

PHYLOGENY.

Not without much trouble have I been able to detach the terminal branch of the Hesperiadæ from what clings, and yet seems not to belong to it, on the lepidopterous tree. From a common pattern with separated veins, the middle branch of the disintegrating median system fading out at length (*in situ*) in both Blues and Skippers, owing to the shrinkage of the connecting cross-vein, the wings of the Lycænids have evidently emerged, losing the gen-

eralized Hesperian number of radial veins in the operation. The principal feature of the Lycænid-Hesperid offshoot is nearly realized by the next departure, that of the Nymphalids, in the "long-fork" of the Charaxinæ. Finally, we find the main branch itself culminating in the Pierids, which, while otherwise agreeing well with the brush-footed butterflies in neururation, are to-day nearly all relatively more specialized, the radius of the primary wings being usually only four-veined, the upper veinlets of the media tending also to travel up the vein and arise from beyond the cell. From this branch of the Hesperiaes I have tried to disentangle the overlapping Papilionides, with their short, free and downwardly curved third anal vein on the fore wings, the second anal vein showing no thinner basal fork, as it does in the Hesperiaes and most of the rest of the Lepidoptera. Even if, as appears to be Mr. Quail's opinion, I have not succeeded in getting rid of this Papilionid spray altogether, I have at least shown that its supposed issue from the Hesperiaes branch, between the Blues and the Skippers, affords no growing point, the two latter being consecutive groups. And this was my main endeavor, to take *Papilio* out from between *Lycæna* and *Hesperia*.

And now having cleared as well as I am able the branch down to the Skippers or Hesperiadæ, let me try to get lower still and find the connection of the Pieri-Hesperiadæ with the trunk of the lepidopterous tree, the Tineides. And here I am met by an obstruction, and also a general prepossession out of which this obstruction arises. I will try to deal first with the prevalent assumption, which is, that the diurnals outrank the rest of the Lepidoptera, are more specialized, and that they represent, so to speak, the outcome of the evolution of the order, which has travailed long to produce them. This view is pictorially represented by all the genealogical trees I have seen, and we may take that of Dr. Packard (1895) as an example. Here the butterflies unfold themselves in the left-hand corner, at the top of the page, and the supporting twigs and limbs are supplied by all the moths, arranged more or less after the catalogue sequence, until we get down to the roots, represented by the Tineina and Erioccephalidæ. How it comes, after such a progression, that the pupæ of the diurnals still show Tineid features, as evidenced by Dr. Chapman, how it comes that the wings of butterflies retain generalized structures as I try to prove, seems, and no doubt is, incompatible with this perfect

scheme. Let us first take up the wings of some moths and show by comparison that they may be more specialized than those of the butterflies.

Specialization is shown by the different groups of the diurnals in a variety of ways and directions. It may be said of the Papilionides, that their main advance is in the reduction of the anal veins of hind wings and the hollowing out of the internal margin of the wing, as shown in an extreme degree by *Parnassius*. Now, when we examine the wings of the Saturnians, we see, in such genera as *Rothschildia*, *Samia* and *Callosamia*, the number of anal veins equally reduced to one, the internal margin equally hollowed out. It may be said again of the Pierids, that their main advance is shown by the diminution of the branches of the radius of the fore wings, which from five in number are reduced to four and three. Turning back to *Rothschildia*, *Samia*, *Attacus*, etc., we find the same reduction. It may be said in turn of the Nymphalids, that their main advance is shown by the opening of the discal cell, the more complete disintegration of the median system of neurulation. Again in the same genera of Attacinae, we find the cell even more completely open, the cross-vein vanished, the centre of the wing longitudinally clean from veins, the median system completely divided between and absorbed by the radius and cubitus (see my figures of Saturnian wings: *Beitrag zur Classification der Schmetterlinge*). Thus the wings of the single Attacid genus *Rothschildia* combine in a high degree the main features of the specializations shown separately by three most important groups of the diurnals. The Attacid wing is far more specialized than the wing of any butterfly. Not only this, it has also lost all residual features which are retained by the butterflies. Let us enumerate some of these: The backward spurs, traces of the base of the median system, to the discal cross-vein, present in many butterflies, are lost. All trace of the cubital cross-vein has vanished from the Attacid primary. This is strong in *Papilio* and allies, quite marked in a number of Nymphalid forms, Morphidæ, Limnadidæ, Heliconiidæ. On the hind wings, the humeral cell, formed by the forking of the radius, closed by the residuary vein R₁, has also gone. This is found, in various stages of completeness, in many butterflies. The humeral spur (precostal spur) of the butterflies has disappeared in the Saturnians, while the frenulum has departed in both groups. If we take the specializations as indicating younger forms, then the

Attacid genera are more modern than the diurnals, which they thus clearly outrank. Now the indications of the base of the median system, the presence of cross-veins, the forking of the radius of hind wings, are primitive or Tineid characters, and the conclusion is here again irresistible, the diurnals are nearer to the Tineid trunk of the lepidopterous tree than the Attacinæ, because they retain more generalized features in the neururation. I think these considerations should divert the general prepossession that the butterflies are the final product of the lepidopterous tree, or that this corresponds in reality with Dr. Packard's plan, which, with all allowances, appears to be still governed by this idea.

The obstruction to proceeding further with the stem of the Hesperiades arises from that extensive group which Dr. Dyar has discussed under the name Bombycides (Agrotides), *Proc. Bost. Soc. N. H.*, 27, 127-147, 1896. I do not think sufficient attention has been paid to Dr. Dyar's separation of the higher moths into distinct phyletic groups upon the characters offered by the position of the larval tubercles. If these characters hold, and the groups established by Dr. Dyar are separate and monophyletic branches of the lepidopterous tree, an immense stride toward our comprehension of the order will have been made. The neururation offers, in the Sphingides, Saturniades, Bombycides, no exclusive character, nothing to absolutely limit these groups or to satisfactorily distinguish them from the Hesperiades. These latter are open to the moths generally, but, if Dr. Dyar's characters hold, I can now sweep aside this vast branch of the Bombycides and account for correspondencies by the fact that the branches have the same origin, but an independent and parallel growth. We need not pass through the Bombycides on the way to the root of the Hesperiades, nor could we very well, seeing they are now about equally specialized. In the same way we may neglect the Sphingides and Saturniades. Arriving in this way at the Tineides, we find in the Tortricidæ a family with partially concealed larvæ, in neururation and wing form having marked affinities with the Skippers. Beyond these are the related Cossidæ, with concealed, grublike larvæ, the neururation generalized in that the median system is complete. Both these families have the thinner basal loop to the second anal vein of primaries in common with other moths. While there may be no positive proof, it seems to me probable that these families of Tinei-

des have been developed from the same phyletic stem which finally produced the Pierids and Hesperiadæ.

If the alternative conclusion be adopted which I have suggested, that the so-called "precostal spur" is really homologous with the "humeral veins" of the Lachneids, we must seek for the origin of the Hesperiadæ in common with that branch of Dr. Dyar's Bombycides in which it is developed, and probably simultaneously from antecedent Tineid types. This would seem to weaken the probability, suggested by Sir George Hampson's phylogeny, that they are derived from forms which have not developed the structure, unless we assume the humeral spurs to be characters of convergence. This humeral vein, which I shall call in the progress of this paper the "humeral spur," is single in the Hesperiadæ, and may be here a survival, others having perhaps disappeared. This survival itself gradually fades away; in *Terias* it is a mere knob, in *Nathalis* it has nearly vanished.

The primitive Hesperiad had probably a wing in which the veins and branches were all separate, the base of the median system more or less fully developed and with the first anal existing. The second median was central. The cubital cross-vein was present. The fork of the second anal was possibly expanded into a longitudinal vein connecting with second anal by a cross-vein. The primitive Papilionid was probably propinquitous, having most features in common, but the third anal was longer and unconnected, and there are indications from the position of the second median that it was not central as in the primitive Hesperiad from the different shape of the discal cell. On the hind wings the primitive Hesperiad would have lost the three outer branches of the radius, but the first would be present, closing the subcostal cell as in the Sphingidæ. On the costal region of primaries the costal vein might have been functional, but it had probably already left the secondaries. Instead there might have been a greater development of humeral spurs.

It will accord best with the paleontological record if we assume an early and comparatively quick evolution for the diurnals, and as in these are included the Papilionides we must finally say a word as to their presumed origin.

I have recorded elsewhere my search for the short downwardly curved third anal vein of the Papilionides' primary wing. Mr. Meyrick having figured it in the Geometridæ, I sought for but

could not verify its existence. Indeed it is quite clear that Mr. Meyrick's figure of the wing of *Venilia macularia* is impossible. For supposing that we could homologize the loop of the second anal with the third anal of the Papilionides, Mr. Meyrick's figure would depict a moth with *four* anal veins to the primary, since both loop and downwardly curved vein are given. It seems as though the fork or loop to the second anal vein must exclude the third anal vein of the Papilionides and should therefore be homologous with it. In the Saturnian genera *Telea* and *Actias* the loop is continued as a short spur. This looks as though the loop might be the remains of a longitudinal third anal vein, which has been joined to the second anal by a cross-vein, while the external portion has afterwards degenerated.

This view is supported by the fact that the prolongations to the pure and simple loop appear in the Tineid families Cossidæ and Psychidæ, but, in either case, the diphyletism of the diurnals is untouched, since we can reach the *Cossidæ* without again meeting the free and downwardly curved third anal vein of the Papilionides. The third anal would have been merely connected with the second in one line and not in the other. At this moment the Papilionides hang in the air and their ancestry is undiscovered. We may suppose them to have been evolved at the same geological period with the Hesperiadæ, whose origin we can trace, and that the record has in their case become lost.

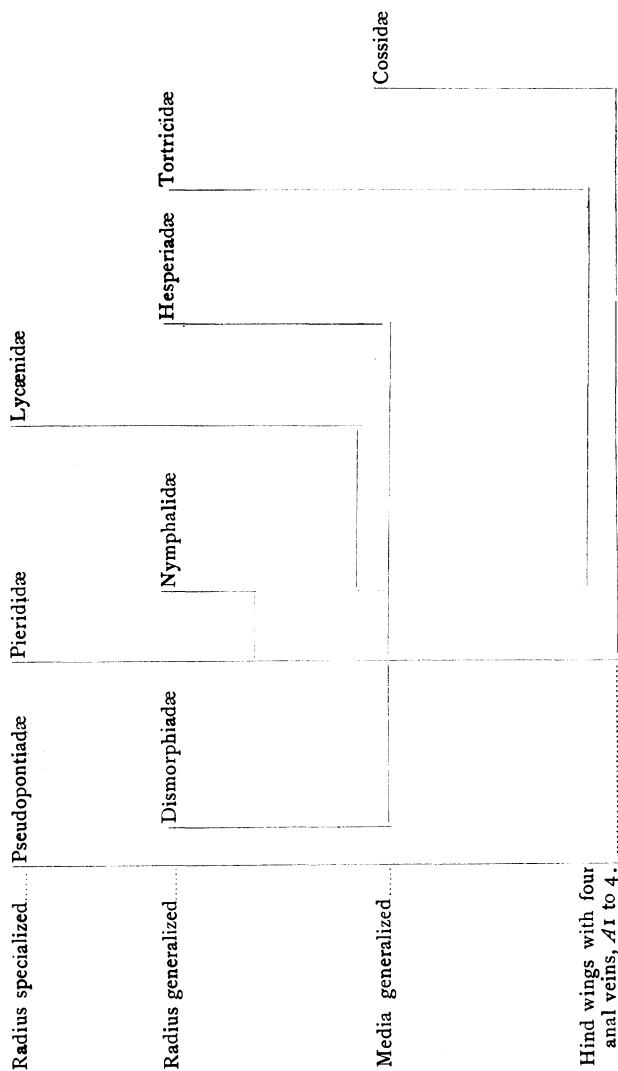
ABERRANT TYPES.

Having thus indicated the course probably taken by the ancestors of the two divisions of the butterflies (Lepidoptera which of old loved light rather than darkness and hence may have become what they are), we can turn to a brief consideration of three dissonant minor groups which hang upon the skirts of the Pierids without any traceable connection. These are the Leptidianæ, the Dismorphianæ and what we must call the Pseudopontiadæ, for, according to a note in the *Entomologist's Record*, Mr. W. F. Kirby has shown that *Pseudopontia* of Plötz antedates by a little *Gonophlebia* of Felder, and Mr. Scudder's statement that we should prefer the latter is thus amended. The two former groups seem closely allied by the extraordinary character of the cubital movement of the middle vein of the median series. The Leptidianæ are pecu-

liar in the absence of the fork to the second anal vein of the fore wings. They are thus comparatively specialized, although the radius retains the five branchlets. The common characters of the two groups with their five-branched radius and elongate wings apparently warrant a phylogenetic association, though in their special features sufficiently distinct. The species are, technically speaking, "long wings," forms in which the primaries have the branches of the radius removed outwardly, sometimes, as here, entirely beyond the cross-vein of the discal cell. The passage of the ordinary broad-winged type into that of the "long wings" I have recorded in the Nymphalids. Since I find no connection here of the two types of wing I have separated the Dismorphiadæ from the Pierids, and exclude them when using in this paper the latter term.

The single species and type of the Pseudopontiadæ may be called, in contradistinction perhaps to almost all other Lepidoptera, a "round wing." In this place it is sufficient to state that the neuration is extraordinarily specialized. The radius is only three-branched and the median series shows the Pierid movement in specialization, the two upper branches both actually ascending the radius. But on the hind wings three anal veins have been preserved, and the origin of this isolated type must be sought for at a period when this structure prevailed. It may have survived in this instance owing to the necessity for sustaining the spherical shape of the wings. We may now connect this form directly with Tineides which have the same three anal veins on the hind wings present. Consult figure, PROC. AM. PHIL. SOC., xxxvii, Pl. I, Fig. 7.

PROBABLE PHYLOGENY OF THE HESPERIADES.



CLASSIFICATION.

The characters used in the following table are not exclusive, but serve to distinguish the material here discussed :

Hind wings with a single anal vein..... .PAPILIONIDES.

- Hind wings with two anal veins. HESPERIADES.
 Radius of fore wings 3 to 5 branched; first radial branch
 from above cell; *M*₂ radial. PIERIDIDÆ.
 Radius of fore wings 5 branched; all radial branches arising
 beyond cell; *M*₂ central or cubital. DISMORPHIADÆ.
 Discal cells not reduced; the cross-vein concave; *M*₂
 cubital on fore wings. *Dismorphianæ*.
 Discal cells reduced; the cross-vein convex; *M*₂ central
 on fore wings *Leptidianæ*.
 Hind wings with three anal veins. PSEUDOPONTIADÆ.

Family DISMORPHIADÆ.

Wings entire; fore wings with the radius 5 branched, all the short branchlets arising equidistantly beyond the cell. Cells closed; middle branch of the median series central or cubital. I find only doubtful traces of the fork to second anal vein of primaries at base. In the *Dismorphianæ* the male primary is narrow; hind wings sometimes much enlarged inferiorly; no trace of costal cell; middle branch of median series cubital; two anal veins.

Subfamily *Leptidianæ* Grote, 1897.

Wings entire, elongate, proportionate. Middle branch of median series central on primaries, cubital on hind wings. Cells closed, reduced to basal third of wings; cross-vein outwardly convex. No trace of fork to second anal on primaries. Secondaries not enlarged, proportionate.

Outer margin of fore wings acuminate between first and second median branchlets, second and third median propinquitous at base on cross-vein. *Azalais*.

Outer margin of fore wings not acuminate; second and third median branchlets separate at base. *Leptidia*.

Azalais n. g.

Type: *Leucophasia gigantea* Leech, *Ent.*, 23, 46, 1890.

Azalais gigantea.

A more specialized form than *Leptidia*, as shown by the approximation of the second and third median branchlets on hind wings, the two branches arising close together from the point of convexity of the cross-vein. This insect is described and figured in the *Butterflies of China*, p. 484, Pl. 36, Figs. 10, 11, 1893.

Gen. *Leptidia* Bilberg, 1820.

Type: *L. sinapis*.

Syn. *Leucophasia* Stephens, 1827.

Leptidia sinapis.

This common European species differs from *Azalais* by the characters given in the above table. From the neurulation the genus *Leptosia*, with the type given by Scudder, does not belong here. In the *Handbook of British Lepidoptera*, Mr. Meyrick places *Leptidia* in the Pierididæ, between *Euchloe* and *Pieris*.

The wings of the Leptidianæ show apparently no sexual character in size and shape, whereas, in the Dismorphianæ, the males have the primaries narrowed and the secondaries disproportionately widened.

Subfamily *Dismorphianæ*.

This subfamily is closely related to the preceding, but differs by the sexual disproportion of the wings in the males of the genera allied to *Dismorphia*, and by the longer and narrow discal cells. I can find no traces of the fork to the second anal vein of fore wings at base except doubtfully in *Acmepteron*. The Dismorphianæ agree in the cubital position of the middle median branch, but this position is assumed on *both* wings, hence it would be herein a more specialized group than the Leptidianæ. The parallel between these two groups and the Heliconiidæ is shown by the neurulation, in that the radial branches tend also in the latter family to arise beyond the cell. Neither in this group nor the Leptidianæ are there any traces of the cubital cross-vein, hence they are more specialized forms than the Heliconiidæ. It is possible the coincidences indicate that they had a common origin, but against this view the fact of the cubital position of the second median branch, as contrasted with its radial position in the Heliconiidæ and the brush-footed butterflies, will militate. The discal cross-vein is, however, concave on fore wings as in the Heliconians, but since it is convex outwardly in the Leptidianæ, which otherwise so well agree, the character will not have much weight. The broadened hind wings of male *Dismorphia* recall in shape those of *Pseudopontia*.

The Dismorphianæ are remarkable in the cubital position of the middle median branch of fore wings, and this position within the Hesperiadæ is only repeated apparently in certain Giant Skippers, Megathymidæ, which I have had no opportunity to study closely.

A trace of this tendency is, however, visible in the Skipper *Angiades sylvanus*. Here, on the fore wings, this vein, M_2 , still keeping central, has succeeded in sustaining its connection with the cubitus by a true vein; that is, the lower part of the cross-vein between M_2 and M_3 has retained its functional character, while the upper portion, between M_2 and M_1 , has yielded to disintegration and become a scar. Hence M_2 is still fed from the cubitus. On the hind wings vein M_2 has failed to retain the connection, the source of blood supply has given out with the disintegration of the entire cross-vein, and, in consequence, this middle branch of the media has almost entirely vanished from the surface of the wing.

Of the genera of the Dismorphianæ, Mr. Scudder gives the type of *Dismorphia* : *laia*; of *Leptalis* : *astynome*. Additional genera are given by Dr. Dixey in a footnote, *Trans. Ent. Soc. London*, 1896, p. 65. Mr. W. F. Kirby kindly informs that the types of these are : of *Pseudopieris* : *nehemia*; of *Enantia* : *melite*; of *Moschoneura* : *methymna*. Of these types I have been unable to procure specimens of the first and last for study.

Gen. *Leptalis* Dalman, 1823.

Type : *L. astynome*.

Leptalis astynome.

Radius five-branched, all the branches arising beyond the cell; R_1 fusing above with subcostal vein. Cell closed, long and narrow; cross-vein deeply concave, somewhat weakened. First median branchlet arising at junction of cross-vein with radius; M_2 cubital. No trace of fork to second anal. Hind wings with hardly abbreviate somewhat pointed costal, curving toward base of wing; no trace of subcostal cell. First median branchlet has left cross-vein and arises from radius at about one-third of the length from cross-vein to external margin. Cell closed; M_2 cubital.

This genus is, perhaps, less specialized than *Pseudopieris*, in which the discal cell is superiorly retreated, leaving M_1 to spring from radius beyond it. It is more specialized than *Enantia* (to which it stands nearer) and *Acmepteron*, because in these the first median branchlet still remains on the cross-vein.

Leptalis melia.

I describe this since the species has become well known, owing to its having been cited by Fritz Müller as an example of the primi-

tive type of coloration of the genus. It is very close to *astynome*, but represents a slightly more generalized type and must be considered thus a more primitive form. It differs by the minute character that the first median branchlet appears as a continuation of the cross-vein from its upper corner; in *astynome* the fusion of the upper wall of the vein with the radius can be made out. The radial branchlets are a little longer, but R_1 equally fuses with the subcosta. On hind wings M_1 ascends the radius for a shorter distance, lagging thus behind *astynome* and much as in *Enantia*. Since I am not in a position to compare *Dismorphia*, I cannot conclude as to the absolutely right place for *melia* and leave it under *Leptalis*. Color and pattern do not move necessarily with neuration and at times (as in *Cunizza hirlanda*) are much at variance. *Leptalis melia* is a more specialized insect, so far as the neuration is concerned, than those forms of *Dismorphia*, now to be described, in which M_1 still clings to cross-vein before the upper angle of cell. From its position with regard to *astynome*, it might have served as a palette upon which the heliconine pattern of the wing was subsequently traced, but I think not, the differences in neuration being so very slightly to its disadvantage. The costal humeral spur of hind wings is as in *astynome*. *L. melia* appears as a natural specialization of *Enantia milete*.

I will first take up a form which stands a little apart from the others here treated of:

Gen. *Pseudopieris* God. and Salv.

Type: *P. nehemia*.

Pseudopieris nehemia (Boisd.).

Radius five-branched, all the branches arising beyond the cell. R_1 not fusing above with subcostal vein, but free. Discal cells closed, but curiously retreating superiorly on both wings; the cross-vein here falling back toward base of wings and leaving M_1 stranded and fused with radius, at a point opposite M_2 , so that it has made no independent radial progress. On hind wings the humeral spur is straight, truncate, terminating in a Y-shaped projection.

This form differs from all others examined and the genus is undoubtedly valid, while the rest hold more or less together as phases in a progressive common specialization of the neuration.

Gen. *Enantia* Hübner, 1816.Type: *E. melite*.*Enantia melite* (L.).

Radius five-branched, all branches arising beyond cell, but compared with *Leptalis*, the first radial is less advanced, much nearer cross-vein, hence in a more generalized condition. *R*₁, angulate, fusing with subcostal. Cell closed, concave; *M*₁, from cross-vein close to radius; *M*₂, cubital. Hind wings with hardly abbreviate, somewhat pointed costal, turning well to base of wing; no trace of subcostal cell. First median branchlet has left cross-vein and arises from radius at somewhat less than one-third of its length from cross-vein to external margin. Cell closed; *M*₂ cubital.

This form is more generalized than *Leptalis*. Mr. Scudder takes *licinia* as the type of *Enantia*, but, for several reasons, I follow Mr. Kirby here.

Gen. *Acmepteron* God. and Salv.Type: *A. nemesis*.*Acmepteron nemesis* (Latr.).

Radius five-branched, all the branches arising beyond discal cell; *R*₁ fusing with subcostal vein. Cell closed; cross-vein medially concave; *M*₁ arising much before upper angle from cross-vein, hence this genus is more generalized than *Enantia*; *M*₂, cubital; from the concave portion of cross-vein a strong backward spur arises, the relic of base of the median system. Hind wings with humeral spur straight, truncate; cell closed, with *M*₁ arising at upper extremity of cross-vein, hence much generalized.

This genus comes nearest to the primitive type of the subfamily, being more generalized than any examined by me. There is a difference in the degree of sinuosity of the second anal vein, which is much bent in *Acmepteron*, but which I have not been able to precise. In this form also I believe to have detected a very faint linear scar at base of second anal, and which I cannot make out in the other genera of the family. It would occur naturally in a generalized form, but, as I have said elsewhere, the detection of the scar, when faded, is quite difficult and depends on the light in which the tegument is viewed.

CONCLUSIONS ON THE DISMORPHIADÆ.

This small and peculiar family is of the utmost importance as bringing evidence of the solidarity of the Hesperiadæ as classified by me. The generalized features are distinctly those of the Skippers. The five-branched radius has the branches all equidistant, and they distinctly recall, in their position and course, the branches of the Lycænidæ and Hesperidæ. The radial branchlets have moved along; R_4 has crept up R_5 till it becomes a short fork. The cubital position of the second median branchlet shows the probability that the group, exhibiting a character which comes out in the *Megathymidæ*, and which is dormant in the Skippers proper, has left the main stem when this feature was in abeyance. That the forms are now relatively specialized is shown by the faded-out fork to the second anal of primaries. In specialization the branchlets of the radius have moved outwardly, keeping up their equidistant character. This is another link showing that the butterfly wing had originally separate veins and a five-branched radius. Relics of this type are afforded by the Charaxinæ in the Nymphalids. All these butterfly families converge, and the discovery of a comprehensive type would make easy what now must be pieced out with much care and thought. At present the butterflies are all greatly specialized, but the generalized characters are still there in fragments and can be put together. To these all the families contribute their quota. The Papilionides remain excluded, from their peculiarly placed third anal vein of the primary wing. As I have repeatedly said, granting the homology of the fork attached to second anal vein of the Hesperiadæ, with the short, downwardly curved third anal vein of the Papilionides, the diphyletism would be shown in the fact that the third anal has joined the second anal in the one case and remained free in the other. How important this is may be inferred from the fact that the first position is held unchanged to the Tineides through immense series of forms in all conceivable conditions of specialization, while that of the Papilionides is equally tenacious through a small group of genera of very diverse shape and appearance.

Family PIERIDIDÆ.

Wings entire, primaries broad trigonate, secondaries full, rounded, rarely with projections. Radius three to five-branched, cells closed, sometimes partially degenerate, again with slight backward projec-

tions, indicating the vanished base to the median system. The two upper branches of the median system ascending the lower side of the radius in specialization. (The second branch follows suit in *Phulia* as well as in *Pseudopontia*.) M_2 radial. The fork to the second anal vein of primaries is usually, perhaps always, present, rigid, very thin and transparent. Hind wings with the subcostal cell lost, the subcostal vein solid at base; in some species, *e. g.*, *Hebomoia glaucippe*, there is a narrow slit perceivable. I have therefore assumed that all traces of R_1 have generally disappeared and lettered the Subcosta S. alone; the fact that the radius is theoretically furcate at base has no practical value here. The humeral spur (precostal spur) is usually present; in some specialized forms, *e. g.*, *Nathalis*, *Colias*, it has vanished; in some subspecialized genera, *Eurema*, *Zerene*, *Phæbis*, it has left a slight projection. Discal cell of secondaries closed. M_2 radial. Two anal veins. As compared with the Lycæni-Hesperiadæ branch, the neuriation shows more complex changes, the relations more netlike.

No characters of the wings, or, in fact, other, have been found by me by which a subdivision of the Pierididæ could be effected. Where there are no gaps there are no categories. The genera stand in various degrees of relationship toward each other; there is a tendency to form lines, culminating in a form with three radial branches, terminating in one with the generalized number five. I have indicated these lines in a former communication to the American Philosophical Society. The phylogenetic lines come out more clearly in the holarctic fauna; as we approach the tropics the increased number of forms render their separation quite difficult. I have no doubt I have often failed to give the true relationship; at least, I have tried to do this, to express by a lower position the fact that the form so placed displays here a neurational feature which a succeeding form has abandoned; this is in principle what is intended by phylogeny.

A rough division into "Whites" and "Yellows" from the prevailing colors of the wings has been attempted. Since these groups cannot be actually limited, they merit no Latin term. As often as I have tried to express their characteristics I have desisted, fearing to dwell upon exclusive marks. In *Pieris* and *Colias*, or *Eurymus*, we have a typical expression of the two associations, which are possibly really natural groups kept apart by general color.

Since the most specialized form I have found belongs to the im-

mediate line of the typical genus *Pieris*, I have commenced with the "Whites;" but since the lines probably really converge, it is not more correct than to begin with the "Yellows."

Typical "Whites."

(Pieridini.)

Gen. *Phulia* H.-S., 1867.

Type: *P. nymphula*.

Phulia nymphula. Staudinger, *Iris*, vii, Taf. i, Fig. 5 (neururation).

Radius three-branched; R_1 and R_2 before the cross-vein, R_3 –5 to costa just before apex. Only the lower median branchlet from cross-vein; M_2 from lower side of radius not far from cross-vein; M_3 a short furcation not far from apex. I cannot make out any trace of the fork to second anal; since this form is extraordinarily specialized by the ascension of the radius by M_2 (paralleled in *Pseudopontia*), its absence might be expected, yet I have so often found traces of it in the Pierididæ where I thought it absent, that it may be finally detected here. Secondaries oblong ovate, humeral spur pronounced, turning to base of wing; first and second median together from upper angle of discal cell. No traces of subcostal cell.

From excellent figures of the neururation of species of *Phulia* given by Dr. Staudinger, *Iris*, vii, Taf. i, *Phulia nympha* Staud. would be slightly more generalized by the propinquity of M_2 to the cross-vein (compare with Fig. 5 of *nymphula*). The species of *Phulia*, as well as the following *Trifurcula*, are Andean, flying at a height of 3000 to 5000 metres, department of La Paz, Bolivia.

Gen. *Trifurcula* Staud.

Type: *T. huanaco*.

Trifurcula huanaco. Staudinger, *Iris*, vii, Taf. i, Fig. 7 (neururation).

Radius four-branched; R_2 advanced to opposite discal cross-vein; R_3 a very short furcation. M_1 , ascending radius; M_2 from cross-vein near to radius, so that the three veins are brought here close together, a feature which Staudinger considers characteristic. A very faint trace of fork to second anal. Hind wings shaped like *Phulia*; humeral spur straight, abbreviate; no trace of subcostal cell; M_2 radial.

More specialized than *Pieris* by the advance of R_2 to a point

opposite cross-vein ; more generalized than *Phulia* by the four-branched radius and M_2 still from cross-veins.

Gen. *Mancipium* Hübn., 1806.

Type : *M. brassicæ*.

Mancipium brassicæ. Grote, *Mitt. a. d. Roem. Mus.*, 8, Taf. i, Fig. 4 (neururation).

The validity of this genus seems to depend upon the fact, that in my preparations the short fork, R_3 of *Pieris*, has disappeared. Dr. Chapman informs me that in material examined by him the veinlet still shows itself. *Mancipium* is then a *Pieris* with sometimes three-branched radius. It shows that there exists a tendency in *Pieris* to lose R_3 ; the individuals not reproducing the vein are specialized, those repeating it relatively generalized. The genus stands on a very uncertain footing and should probably be dropped ; it can only be used with any separate meaning for a part of the material of the typical species. *Pontia daplidice*, usually mixed with *Pieris*, may owe its similarity, I have ventured to urge, to convergence and belong really to the line Anthocharini. The generic title *Mancipium* covers the *Pieris* of the future, not of the present day, since any *Pieris* discarding the short veinlet R_3 would become thereby equally entitled to be referred to it. From the neururation, I cannot distinguish *Pontia* from *Mancipium*.

Gen. *Pieris* Schrank, 1801.

Type : *P. rapæ*.

Pieris rapæ. Grote, *Mitt. a. d. Roem. Mus.*, 8, Taf. i, Fig. 5 (neururation).

Radius four-branched, R_2 from above cell before cross-vein, R_3 a very short fork before apices. Discal cross-vein shrunk ; M_1 from radius, M_2 radial, quite close to upper angle of the cell. Fork to second anal at base distinct. Hind wings with humeral spur turned outwardly ; no subcostal cell, but the vein seems to show a cleavage, its remnant. Discal cross-vein also medially deteriorate ; M_2 radial.

Pieris napi.

Agrees closely with the preceding, but the second radial is advanced nearer the cross-vein (emulating *Trifurcula*). The fork R_3 is still shorter, quite minute and I should expect it to be occa-

sionally absent, when the specimen would be referable to *Mancipium*. *P. napi* is thus more specialized than *P. rapæ*.

We have thus come somewhat rapidly from local butterflies living on the heights of the Andes to the typical genus of the holarctic Pierididæ. It is clear from the retention of *R*₂ above the discal cell, that the ancestors of *Phulia* have passed through the type of *Pieris*. *Trifurcula* seemingly represents an intermediate but lateral stage, in which *R*₂ is advanced to opposite cross-vein, while *M*₂ has not followed *M*₁ and left the cell. The specializations are therefore probably independent and *Phulia* has not passed through a *Trifurcula* stage.

The genus *Pieris* represents an advanced type of the four-branched radius, on the verge of becoming three-branched, but one in which the second radial has retained its original position above the cell. This type may be used for comparison with the other genera, some of which have evidently attained, through convergence, the same condition; while on the passage of the five-branched to the three-branched form the stage of *Pieris* is more or less nearly repeated in different phyletic lines. For instance, in the "Yellows," *Callidryas* represents *Pieris*, with *R*₂ still in position, but it falls behind in the long *R*₃. *Zerene* abandons the original position of the second radial, which advances to opposite cross-vein and repeats the *Trifurcula* specialization. *Eurymus* (*Colias*) goes still further, *R*₂ passing beyond the cell and the fork of *R*₃ shortening to nearly the condition of *Pieris*. Thus we can probably use the type of *Pieris* with advantage to make the position of the other genera clearer.

Although *Phulia* has made an immense stride beyond *Pieris* toward a greater simplification of the neurulation, as shown in the ascent of the radius by *M*₂, in the short fork of *R*₃₋₅ with *M*₁ (through which we can imagine that the two may come to fall together), yet does *Phulia* remain on the *niveau* of *Pieris* by the retained position of *R*₁ and *R*₂. This fact illustrates the inequality of the specialization, in one and the same organ, of the characters we use as generic. This is a further amplification of that inequality of the specializations between the different stages of the insect to which I ventured to draw attention in 1875. It will then be impossible to "reconcile" generic groups founded on the separate specializations of larva, pupa or imago. Primary, *i. e.*, indifferent characters may be found, by which great groups can be

approximately outlined. But the characters used as generic are subject to constant modification and this from the total surrounding. And for larva, pupa and imago the *entourage* is quite distinct and as for different animals. It is this want of correspondence which shows itself upon occasion, together with the baffling features of convergence which makes the task of the zoölogist in unraveling phylogeny so extremely difficult. The classificatory strain put upon the features of specialization, as for instance by Dr. Karsch's system based upon the larval feet, or Dr. Dyar's foundation of the family Apatelidæ, is greater than they can bear.

My conclusion is, that, there being no homology between the specializations of the different stages in the Lepidoptera, there is also no correspondence.¹ It may be, in certain cases, that all three show marked specializations after their differing fashion, but there exists no necessity that they should do so. One specialization does not arise out of another. The very unusual larva of *Stauropus* produces a moth not so different from other Ptilodonts, as for instance *Heterocampa*. To revert to the genus *Apatela*, from which I drew my earliest deductions in this matter, if the curious clubbed or flattened hairs on the body of the caterpillar of *Jocheæra alni* and *funeralis*, were found instead on the body of the moth, our critic would reproach us with "ignorance" were we to overlook this generic character. A specialization is, however, a generic character, in whatever stage it presents itself, and in overlooking this in the larva our critic is himself at fault. *Jocheæra* cannot be thrown into the common pot of *Apatela* without covering over its peculiar specialization, and to do this is, to use for once a term I dislike, unscientific. A peculiar generic title simply means, that the insect possesses some peculiar feature, in whatever stage, that distinguishes it from its allies. There is, however, no test for the amount of the specialization necessary to support an independent title. To weigh the value of the categories, without prejudice, is the test of a capable classifier. I am not one of Mr. Butler's censors for his paper on *Apatela*, a paper both suggestive and challenging con-

¹ That variations in color in the preceding stages have no influence on the imago seems certain. From the two types of the pupa of *Papilio machaon* I have reared but one of the butterflies. Oscar Schultz separated aberratively colored larvæ of the same species, and they all produced normally marked and colored specimens. Aside from sexual peculiarities, there is then no necessary correspondence between the stages in this respect.

sideration, the more so since his critics do not seem to have been able to point out wherein his conclusions are really faulty. It is that Mr. Butler here mistook characters of convergence in the larvæ of *Apatela* for characters of affinity, and this we can control by a study of both moth and chrysalis. Furthermore, Mr. Butler placed a classificatory strain upon these characters, which they cannot carry, in giving them family value. Their value is generic, however much or little the moths agree; the conclusion is irresistible: we should use the larval specializations as the basis of generic names for the total cycle, if we are entitled so to use the specializations of the imago.

To continue our researches for generalized forms of the direct *Pieris* line, it is clear that we must confine ourselves to those in which the first two radials are in position above the cell, since the departure of *R*₂ toward the tip of the wing is a further specialization which we can even conceive *Phulia* has yet to undergo.

Gen. *Huphina* Moore.

Type: *H. coronis*.

Huphina coronis.

Radius four-branched, *R*₁ and *R*₂ in position above cell, but as compared with *Pieris*, not so advanced along the vein. The neururation agrees with that of *rapæ*, but all the movements are retarded and show thus a preceding stage to that of *Pieris*. The fork of *R*₃ with *R*₄ and 5 is longer. The cells are closed; on primaries *M*₁ ascends the radius for a shorter distance than in *Pieris*. On hind wings the humeral spur is pointed, turned outwardly. An antecedent stage of *Pieris*, which the latter has abandoned. The wings are of a similar texture with transparent veins.

Huphina judith.

Agrees with *coronis*, but slightly more specialized; *R*₁ and *R*₂ are nearer together, but *R*₂ is further from the cross-vein than in *Pieris*. Wings more produced; the outline differing.

We now come to two genera which agree with the *Pieris* plan generally in neururation, but have produced primaries and light, bright colors and represent two stages in specialization wide apart.

Gen. *Tachyris* Wallace, 1867.Type: *T. nero*.*Tachyris nero*.

In the shape of the more pointed primary wings differing from *Pieris* and *Huphina*, the neururation agrees generally and the specialization seems to even exceed the latter. Radius four-branched; R_1 and R_2 nearer together than in *Huphina*; apical fork even shorter. Cell closed; M_1 has ascended radius for about one-fourth of the distance from cell to margin; cross-vein between M_2 and radius concave; a slight mesial backward spur. Hind wings with humeral spur turning sharply outwardly.

There are apparently four groups in this genus as established by Wallace, but I have only examined the type as given by Mr. Scudder (*Hist. Sketch*, 274).

Gen. *Hebomoia* Hübner, 1816.Type: *H. glaucippe*.*Hebomoia glaucippe*.

Agrees with *Tachyris*, but much more generalized, and there is a wide gap in the continuity which may be bridged over by forms to which I have not access.

Radius four-branched; R_1 and R_2 approached, but R_2 well removed from cross-vein. Cells closed; M_1 has not ascended the radius, as in the entire preceding series, but springs from cross-vein close to upper angle of discal cell. Traces of the base of media as in all generalized forms; two parallel creases can be made out, the upper joining to a slight backward spur at the origin of M_2 , the lower from a similar point at the centre between M_2 and M_3 . First anal vein a very strong scar; this vein is only developed, however, incompletely in generalized forms. A strong fork to second anal at base. Hind wings with pointed humeral spur turned sharply outwards. Traces of a splitting of S at base, thus of a subcostal cell. Wings with transparent but strong veins.

This is the most generalized form which I can refer to the probable direct line of *Pieris*; it is a long way behind, from the fact that M_1 lags upon the cross-vein. The line of *Pieris* seems to have connected with the *Aporia* line, which we now take up, and through forms like *Thestylis*, which may almost belong to either.

The neururation of *Hebomoia* is Pierid, not Anthocharid; the ornamentation of the wings above resembles on the other hand that of *Eroessa*, but also *Callosune*. I cannot see in the neururation any sure indication that it is related to the "Yellows." Probably all the generalized forms tend to meet, but I have found no comprehensive type in my material which might stand as ancestral to the whole.

A line which runs parallel with *Pieris*, and which is characterized by the opaque veins, strong wings, the two first radial branches in original position above the cell, the humeral spur of secondaries turned outwardly except in *Mesapia*, where it is truncate, and which possibly may connect with the main line through *Prioneris*, may now be taken up.

Gen. *Mesapia* Gray, 1856.

Type: *M. peloria*.

Mesapia peloria.

A miniature edition of *Aporia*. Veins strong, cells closed. *R*₂ more separate from *R*₁ and a very little nearer end of cell; the costal field above cell is wider on primaries, the cell a little more central than in *Aporia*. On secondaries humeral spur straight and truncate. Seems a slightly more specialized form than *Aporia*, with which it generally coincides even to the fraying of the cross-vein superiorly between *M*₂ and *M*₃ on fore wings. On the hind wings the veins appear more equidistant, *M*₁ is further removed from *R* than in *Aporia*. A rare form from Thibet.

Gen. *Aporia* Hübner, 1816.

Type: *A. cratægi*.

Aporia cratægi. Grote, *Mitt. a. d. Roem. Mus.*, 8, Taf. i, Fig. 6 (neururation).

Wings strong, entire veins opaque, cells closed. Radius four-branched; *R*₁ and *R*₂ in original position above cell, but *R*₂ removed a little outwardly. *M*₁ from radius, well removed from cross-vein; the branchlet *R*₃ longer than in *Pieris*. Second anal vein with a slender fork at base. Hind wings with humeral spur abbreviate, turned outwardly. A common European form.

Gen. *Metaporia* Butler, 1870.

Type: *M. agathon*.

Metaporia agathon.

Closely allied to *Aporia*, but the first and second radial branchlets are quite in original position, R_2 further from the cross-vein, hence more generalized than *Aporia*. On hind wings humeral spur straight, truncated.

Dr. Staudinger catalogues under *Metaporia* a number of rare palæarctic forms which I have not been able to study, and which may not be congeneric with *agathon*, which the same author refers to *Pieris*.

Gen. *Prioneris* Wallace, 1867.

Type: *P. thestylis*.

Prioneris thestylis.

Wings ample, entire, veins opaque, tending to subtransparency. Radius four branched; R_1 and R_2 near together, well removed within cell, R_3 a moderate fork. Cells closed; M_1 ascends radius for about one-fourth of distance between cross-vein and external margin. Hind wings with humeral spur pointed, turned to apices of wing. Cross-vein, between M_2 and cubitus, strongly convex with M_3 nearly centrally placed, springing from apex of convexity; traces of a splitting of subcostal vein at base.

This genus is more generalized than *Metaporia* by the two first radial branchlets being less outwardly removed; the first median has ascended radius for a shorter space; on hind wings M_2 is more central, continuous with cross-vein. It is more specialized than *Hobomoia*, by the ascent of radius by M_1 . On both wings M_2 is continuous with upper portion of discal cross-vein, which latter, between M_2 and M_3 , is slightly reduced.

We will now leave *Pieris* and its branch *Aporia* and seek for other parallel series of forms. The following line may not be continuous. I arrange the genera according to their grade of specialization.

Gen. *Elodina* Felder, 1865.

Type: *E. egnatia*.

Elodina egnatia.

Wings entire; radius specialized, three-branched; R_2 has left the discal cell and progressed beyond the cross vein, being intermediate between R_1 and $R_3 + 4 + 5$, the latter a long fork with

M_1 , which ascends the radius to a little less than one-third of the distance between cross-vein and external margin. Cell closed, the vein a little degenerate, concave, M_2 being thrown off from upper corner and apparently fuses with radius. A trace of fork to second anal. Hind wings with humeral spur straight, apparently turning outwardly at tip; subcostal vein solid at base; discal cell closed, cross-vein somewhat reduced.

A highly specialized form, as seen by the three-branched radius, the ascent by M_1 of the radius and the position of M_2 on the primary wing. The following represents a more generalized stage:

Gen. *Phrissura* Butler, 1871.

Type: *P. ægis*.

Phrissura ægis.

Wings entire; radius four-branched; R_2 has not left the cell, but is advanced nearly to cross-vein; R_3 a short furcation out of $R_4 + 5$. Cell closed; M_1 ascends radius; M_2 radial, out of cross-vein which is concave between radius and M_2 . Trace of fork at base of second anal. Hind wing with humeral vein pointed, turning sharply toward apices.

This type very nearly assumes the stage of *Pieris* and stands much lower than *Elodina*. It is a little more specialized than *Pieris*, since R_2 is nearer cross-vein, not quite assuming the position of *Trifurcula*.

Gen. *Ascia* Scopoli, 1777.

Type: *A. monuste*.

Ascia monuste.

This genus assumes almost completely, apparently by convergence, the *Pieris* stage. The four-branched radius shows the relative position of R_1 and R_2 as in *Pieris*. It is very slightly more generalized than *Pieris*, in that M_2 is further from radius, not continuous with the short cross-vein between M_2 and radius. Hind wings with humeral spur pointed, turning sharply, as in *Phrissura*, toward apices, not abbreviate as in *Pieris*.

Gen. *Mylothris* Hübner, 1816.

Type: *M. rhodope*.

Mylothris rhodope.

Wings ample, entire; radius four-branched; R_1 and R_2 in the *Pieris* position; fork of R_3 with $R_4 + 5$ longer than in

Pieris and *Ascia*, which agree, hence a little more generalized. M_1 ascends radius; M_2 in stage of *Ascia*. Trace of fork at base of second anal. Hind wings with humeral vein as in *Ascia*, pointed, turning sharply toward apex of wing.

There is probably a direct descent between *Mylothris* and the much more generalized *Nepheronia*. I interpolate, however, here the intermediate genus *Ava*, which, more generalized than *Mylothris*, probably connects with the *Ascia* line.

Gen. *Ava* de Nicéville, 1898.

Type: *A. affinis* (Voll.).

Ava affinis.

Wings ample, entire; radius four-branched; R_1 and R_2 in the Pierid position above cell; R_3 a rather long fork out of $R_4 + 5$. Cell closed; M_1 ascends radius, perhaps for a little shorter distance than in *Ascia*, than which it would be thus more generalized; M_2 is also a little further from radius than in *Ascia* and the cross-vein between them is concave or depressed, not straightly oblique. Trace of fork to second anal at base. Hind wings with humeral spur pointed, turning sharply toward apex of wing.

This genus is of the *Ascia* type, not of *Pieris*. As it is a little more generalized than *Mylothris*, I bring it in here. This is to be seen by the longer apical fork of R_3 ; by the shorter stem of M_1 ; the cross-vein between M_2 is roundedly concave or depressed, not angulate as in *Mylothris*, and the second median standing a little further off from radius.

Gen. *Nepheronia* Butler, 1870.

Type: *N. poppea* (idotea).

Nepheronia poppea.

Wings ample; external margin a little retreating below apices; color and pattern of *Mylothris*. Radius five-branched, generalized, approaching the generalized form of the Anthocharid line; R_1 and R_2 in original position above cell; R_3 and R_4 near apices out of R_5 , comparatively short furcations. Cell closed; M_1 does not ascend radius, but arises out of cross-vein just before radius; cross-vein angulate between M_1 and M_2 , a little degenerate between M_2 and M_3 . Hind wings with humeral spur curving gently toward apex of wing.

This form is the most generalized of the Pieridini of which I have any material. It stands below *Hebomoia* from the five-branched radius, but shows less residual features in other respects.

We now come to two genera (if really different) which appear to stand between *Hebomoia* and the present *Ascia* line.

Gen. *Callosune* Doubleday, 1847.

Type: *C. danaë*.

Callosune danaë.

Wings entire, form of *Elodina* and this approaches the latter by the shape of the discal cells which are somewhat broadened outwardly and short. Radius four-branched; R_1 and R_2 in original position above cell; R_3 out of $R_4 + 5$, a rather long furcation. Cell closed; M_1 does not ascend radius, but fuses with it at upper angle of discal cell; M_2 radial; cross-vein between M_2 and 3 a little degenerate. Hind wings with humeral spur pointed, a little long and turning sharply toward apex of wing.

This and the following are more generalized forms than *Phrissura*, but appear to connect with the line *Elodina-Phrissura*.

Gen. *Anthopsyche* Wallengren, 1857.

Type: *A. achine*.

Anthopsyche achine.

Differs from *Callosune* only as follows: R_1 and R_2 a little more separate at base; M_1 apparently more freely fused with radius; cross-vein between radius and M_2 a little shorter; on hind wings the cross-vein meets the point of junction of M_1 and M_2 , whereas in *Callosune* it meets M_2 before the junction. By these points of difference it seems the more specialized form.

We now come to several isolated genera which I believe to be unequally related to the *Ascia* line or to some of its members as enumerated by me. No doubt more connection might be supplied by material inaccessible to me. They appear to me to be connected here rather than to the line *Pieris-Aporia*, strong-winged, more specialized forms, which I will afterwards consider before going on to the angled Whites.

Gen. *Melete* Swainson, 1832.

Type: *M. limnoria*.

Melete limnoria.

This is, I believe, the butterfly which Mr. Scudder calls "*Melete lycimnia (limnobia)*," *Hist. Sketch*, 215. I suppose "*limnobia*" to

be a misprint for *limnoria*. As I do not possess the means of fully checking this I thought I would be obliged to omit it at first, but I received the butterfly from Dr. Staudinger labeled "*Daptoneura limnoria*." According to Mr. Scudder, *Daptoneura* falls before *Melete*, with which it is synonymous.

Wings entire; apices produced; hind wings with anal angle roundedly produced; veins transparent. Radius of primaries four-branched; R_1 and R_2 in original position above cell, near together; R_3 out of $R_4 + 5$ a moderate furcation to apex. Cell closed; M_2 ascends radius for a brief extent, about one-fifth of distance from external margin to cross-vein; M_2 nearly central; two slight backward projections from cross-vein between M_2 and radius. Hind wings with humeral spur straight truncated.

This butterfly is more generalized than *Mylothris*, more specialized than *Nepheronia*, which it appears to represent in the American fauna. The smooth wings are saturated with a pale yellow, deepening over the secondaries, the outer margin of which latter is bordered by a shade resembling the chrome yellow colored patches at base of primaries in its allies.

Two isolated genera, of differing grade of specialization, may be here considered. They have frail wings and in literature have been associated with *Leptidia* (*Leucophasia*), although the neururation does not appear to me to warrant the inference.

Gen. *Leptosia* Hübner, 1816.

Type: *L. xiphia*.

Leptosia xiphia.

Wings frail; discal cells developed, broadening outwardly, about two-thirds of length of wing. Radius three-branched; R_1 from above discal cell; R_2 advanced to opposite cross-vein, hence assuming the *Trifurcula* position; R_3 to 5 furcating with M_1 which ascends radius for about one-third of distance from cross-vein to external margin. M_2 from upper corner of discal cell, apparently not quite fusing with radius; cross-vein concave. Hind wings with humeral spur appearing curved outwardly at top.

This genus is highly specialized, nearly on a par with *Elodina*. It is not related at all to *Leptidia*, and has more resemblance to *Neophasia*.

Gen. *Leucidia* Boisduval, 1847.

Type: *L. elvina*.

Leucidia elvina.

Wings frail, short, entire; discal cells wide, taking up about half of the length from base; radius four-branched; R_1 in original position; R_2 has advanced greatly, arising beyond cross-vein at about one-fourth of distance to external margin; R_3 a short furcation with $R_4 + 5$. Discal cell closed; M_2 nearly central. Fork to second anal at base apparent. Hind wings with truncate straight humeral spur; M_1 out of radius beyond cross-vein; M_2 nearly central.

More generalized than *Leptosia* by the four-branched radius and equally unrelated to *Leptidia*. This species is very light yellow with dark apices of four wings.

Leucidia brephos.

This is one of the frailest of small butterflies; pure white, the neururation agreeing absolutely with the type, unless it is that the humeral spur is a little shorter, truncated.

This exhausts my material in the *Ascia* direction and we will now return to more specialized types of the line *Pieris-Aporia*.

Piccarda n. gen.

Type: *P. eucharis* Drury, sp.

Piccarda eucharis.

Wings ample. Radius three-branched; R_1 from above cell in original position; R_2 a short fork out of R_3-5 before apices. Cell closed, vein between M_2 and M_3 hardly degenerate; M_2 radial; M_1 from lower side of radius, a little less than one-third of distance between cross-vein and external margin. Second anal with basal fork. Hind wings with hardly abbreviate, pointed, outwardly curved humeral spur; cell closed, vein a little more degenerate than on fore wings; Sc. apparently solid at base.

This genus differs from *Delias*, than which it is more specialized, by the position of M_1 , which is about one-third removed from discal cell.

Piccarda hyparethe Linné, sp.

Agrees with *eucharis*, the stem of M_1 very slightly shorter, hence more generalized. There are probably other Asiatic species to be separated from *Delias* upon the above character.

Gen. *Delias* Hübn., 1816.

Type: *D. egialea*.

Delias egialea.

Radius three-branched; *R*₁ from above cell in original position; *R*₂ a short fork out of *R*₃₋₅ before apices. Cell closed, vein between *M*₂ and *M*₃ somewhat degenerate; *M*₂ radial; *M*₁ from radius immediately beyond cell. Second anal with basal fork. Hind wings with pointed, outwardly curved humeral spur; cell closed, vein somewhat degenerate; Sc. apparently solid at base. Differs from *Piccarda* in the position of *M*₁, which springs from radius quite close to the cross-vein beyond the cell, and hence is the more generalized form.

Gen. *Pereute* H.-S., 1867.

Type: *P. callinice*.

Pereute callinice.

Radius three-branched; *R*₁ only from above the cell, but not in original position, being outwardly removed near to cross-vein; *R*₂ a short sinuate branch anastomosing with *R*₁ just before apices, thus a long supradiscal cell is formed, closed outwardly by *R*₂. Cell closed, vein hardly or not degenerate; *M*₂ central; *M*₁ from radius about one-fourth of distance between cross-vein and external margin, herein resembling *Piccarda*. Second anal vein with thin fork at base. Hind wings with abbreviate humeral spur, not pointed, appearing turned to base of wing; cell closed, vein not degenerate; Sc. apparently solid at base.

This genus, except for the position of costal vein of secondaries, would appear as a lateral specialization of *Delias*. The fusion of *R*₂ with *R*₁ at tip of wing is so extraordinary that I should like to examine more material than is now accessible. Specialization is shown by the outward movement of *R*₁ and *M*₁. On the straighter and rather longer portion of the cross-vein between *M*₂ and radius are too very slight inward projections showing where the vanished base of the median system joined on. In *Piccarda* and *Delias* these projections are barely indicated in the same places by a slight unevenness of the vein. This fact, among others, might show that the three genera are related, since in *Perhybris* there is only one projection in the middle of the shorter discoidal vein between *M*₂ and the radius. In both this form and the more generalized

South American *Archontias* the costal vein of hind wings appears turned in the reverse position from *Delias*, and to the base of the wing. The correspondence, however, in the position of the radial nervules, between *Piccarda*, *Delias* and *Pereute* is very great, but is probably owing in the latter case to convergence. That the first radial does not attain the margin, but fuses with the short second radial, isolates *Pereute* from any other type examined.

Gen. *Archonias* Hübn., 1816.

Type : *A. tereas*.

Syn. *Euterpe* Swainson, 1832.

Archonias tereas.

Wings ample. Radius four-branched ; R_1 and R_2 both moved forward, R_2 opposite cross-vein ; R_3 straight, a moderate furcation to apex. Cell closed, vein between M_2 and M_3 medially degenerate ; M_1 from radius about one-fifth distance to external margin from cross-vein. Hind wings with humeral spur turned backwards to base of wing ; Sc. appears to offer a line of cleavage ; cell closed, vein between M_2 and M_3 thinner, but nowhere degenerate.

This genus and the following appear to represent the four-branched stage of the preceding *Pereute*.

Gen. *Catasticta* Butler, 1870.

Type : *C. nimbice*.

Catasticta nimbice.

The primaries are apically narrowed and produced, else this type agrees absolutely in neuration with that of *Archonias*, all the difference I note is that the stem of M_1 is a little longer and that the discoidal vein, between M_2 and radius, is quite even on the inner edge, losing the infinitesimal irregularity of *Archonias*. The produced apices seem to necessitate the wider fork between R_3 and R_4-5 , while R_3 is a little curved. How far these very slight characters are generic I cannot say without a larger material to examine.

We come now to a genus which shows affinities to the Anthocharids in the short terminal branches of the radius of fore wings, as well as in the truncated costal vein of secondaries, curving in one instance plainly to base of wing, and in the comparatively straight inner margin and determinate anal angle of the hind pair.

Gen. *Hesperocharis* Felder, 1862.

Type: *H. erota*.

Hesperocharis erota.

Wings ample; primaries with determinate apices and straight outer margin. Radius four-branched. R_1 alone in original position above the cell; R_2 , 3 and 4 + 5 short branchlets near apex. Cell closed. M_1 still from cross-vein. Secondaries with truncated humeral spur, nearly straight. Space between M_2 and M_3 wide, and here the discoidal vein is distinctly angulate superiorly. Anal angle determined.

This genus and its ally fall below the Anthocharids with four-branched radius, in that M_1 has not ascended radius, but springs from cross-vein before upper angle of cell. I have corresponded with Mr. W. F. Kirby on the subject, who informs me that he believes that *Hesperocharis* might well be subdivided. I find one type among my material which I venture to separate without being able to review all the described species described under *Hesperocharis*. *H. graphites* Bates, a very pale lemon-colored species from Mexico, agrees with the type of *Hesperocharis* in shape of wing, and, as far as I can see without preparing the wings, exactly in neuration.

Cunizza n. g.

Type: *C. hirlanda*.

Cunizza hirlanda.

Wings ample; primaries with rounded apices and outer margin sweeping inwardly. Neuration like *Hesperocharis*; terminal branchlets of the four-branched radius longer. Secondaries with space between M_2 and M_3 narrower, the cross-vein here shorter and not angulate. Humeral spur truncate, clearly turning to base of wing.

The principal distinction lies in the shape of the wings, which in this respect, color and ornamentation approach the line *Neophasia-Perrhybris*. The neuration is more generalized and entirely different from *Perrhybris pyrrha*, which it seems to copy.

Although, from the pattern, the temptation is to consider *Cunizza* a generalized *Perrhybris*, the markings of the former culminating in the latter, still it is not possible to bring *Cunizza hirlanda* into a relation with *Perrhybris pyrrha*, through the neuration. In *Perrhybris* R_1 and R_2 spring from the above discal cell, the Pierine

position; in *Cunizza*, as in *Hesperocharis*, only R_1 remains in position (as in *Piccarda-Delias*), and R_2 and R_3 are short apical branches, succeeding each other out of $R_4 + 5$, the Anthocharid type. The resemblances between *Cunizza* and *Hesperocharis* are too great to be set down to convergence, unless we had other characters. Again, the humeral spur sets toward the apex in *Perrhybris*, the Pierine position; in *Cunizza* it curves in the opposite direction, and this seems to be its trend in *Hesperocharis*, in which it is truncated. Alone the shape of the wings tend to remove *Cunizza* from the *Hesperocharis* and to bring it over to *Perrhybris*. Independent of the fact that the shape of the wings may be also influenced, the resemblance to *Perrhybris* is by no means exact. The apices are bluntly rounded, produced, in *Cunizza*; in *Perrhybris*, though rounded at apices, they bulge between M_2 and M_3 , just where they retreat in *Cunizza*. The latter differs strongly from *Hesperocharis*, where the apices are squared and the external margin descends straightly.

A broken line, which may connect with the main line of *Pieris*, seems to be indicated by the North American Pine Tree White: *Neophasia menapia* Felder.¹ It is possible, also, that *Neophasia* is a generalized form of *Perrhybris*.

Gen. *Neophasia* Behr, 1869.

Type: *N. menapia*.

Neophasia menapia.

Wings somewhat elongated and shaped as in *Delias*, but frail in texture, and in this character resembling *Leptosia*. The *Pieris* type of neuration is nearly repeated. Radius four-branched; R_2 moved forward, but not attaining cross-vein; the fork of R_3 longer than in *Pieris*. Cell closed, the vein between M_2 and M_3 hardly degenerate; M_2 radial; M_1 ascending radius and leaving it about at one-third of total distance from tip of wing. Secondaries with humeral spur turned inwardly at tip, somewhat obscure and truncate; Sc. appearing undivided at base.

In the fact that the feature of *Pieris* is retained, that both R_1

¹ Consult an article by R. H. Stretch, *Papilio*, 2, pp. 105 *et seq.*, for the habits of this insect. Through an apparent confusion of localities, the German lepidopterist Fruhstorfer thought he recognized, in a Pierid flying about meadows in the vicinity of Washington, D. C., this insect, which inhabits Washington Territory and Idaho. See *Insekten Borse*, Nov. 16, '99, p. 279.

and R_2 spring from radius before cross-vein, *Neophasia* agrees with the more specialized *Perrhybris*.

Gen. *Perrhybris* Hübn., 1816.

Type : *P. pyrrha*.

Perrhybris pyrrha.

Wings ample. Radius three-branched; R_1 and R_2 in original position above the discal cell; cell closed, upper half of vein between M_2 and M_3 shrunk, the shorter vein between M_2 and radius strong and showing a central backward projection, the remnant of the base of the median system. Second anal vein with a slender fork at base. Hind wings with humeral spur strongly turned outwardly; cell closed, vein between M_2 and M_3 somewhat shrunk; a single very slight backward projection on cross-vein between M_2 and radius; subcostal vein apparently solid at base.

The correspondence in the neurulation between *Pyrrhybris* and *Mancipium* or *Pontia* may, I think, be due to convergence; otherwise we should have to regard the former as a specialized *Pieris*, of very strange pattern of ornamentation: The stage to which *Pyrrhybris* has attained in the reduction of the radius is anticipatory of *Delias*, but the relationship cannot be considered as direct or ancestral, since the reduction of the media is less advanced in *Delias*. If it were not for the existence of the latter genus, which is clearly ancestral to *Piccarda*, we might regard *Pyrrhybris* as a very early forerunner of the latter. As it is, the line *Piccarda-Delias* has probably emerged from the direct line of *Pieris*, from forms in which the median branches still kept to the cross-vein. The general directions in the reduction of the radial and median branches has been pointed out, and these studies now show the inequality in the rate of specialization between the two systems. In establishing phylogenetic lines we have to reckon with all the factors; in the present paper I am mainly endeavoring to show how the neurulation features may be used, as well as the difficulties they present. I hope to have made it plain that their value is very great, but this will come out more clearly the more material is examined and compared.

In pattern of ornamentation *Pyrrhybris* is dimorphic, and the white color of the male above may be considered historically more recent and a specialization. But, in the veining, the sexes are

alike, hence there has been an independent advance in the pattern of the male.

An analagous difficulty with that in the case of *Pyrrhybris* and *Delias* prevents us from considering that *Neophasia* is related to *Cunizza*; since in *Neophasia* the media has progressed and not in *Cunizza*, where *M*₁ still springs from the cross-vein. But it seems possible that *Pyrrhybris* may be looked upon as a specialization of a type similar to *Neophasia*.

The Angled Whites.

(*Anthocharini*.)

Of the group here discussed, all the types, from the three- to the five-branched form, are, if we admit *Pontia*, here extant, and the evolution of the specialized forms may have been relatively modern. The wings have somewhat sharp apices and often a perceptible sexual distinction in shape, the outer margin retreating in the males. The size is moderate, the ground color white, often with orange blotches in the male, the secondaries marbled beneath with lichen green. The specializations of the neururation run parallel with the *Pieris* branch; in one line the second radial branch remains in the original position, in the other it travels up the vein as it does in *Trifurcula*. The cells are closed; the transparent veins seldom degenerate. Humeral spur of secondaries turned toward base of wing or abbreviate and straight, except in *Pontia*.

Gen. *Pontia* Fabr., 1807.

Type: *P. daplidice*.

Pontia daplidice. PROC. AM. PHIL. SOC., xxxvii, Pl. i, Fig. 1 (neururation).

A specialized form, with three-branched radius. I have discussed (*l. c.*, 35) what I believe has been hitherto overlooked, the fact that this butterfly possibly belongs to the present series, and that its resemblance to *Pieris* (than which it is more specialized) is mainly due to convergence. The second radial arises before the cross-vein, hence it would represent a culmination of the direct line from *Euchloe*. The humeral spur of secondaries turns outwardly as in *Pieris*, and this feature may ultimately prove me to be wrong.

With regard to the use of this generic title, Mr. Scudder says: "Curtis, *Brit. Ent.*, Pl. 48, designates (in 1824) *daplidice* as the

type, which must stand, although seldom used in this manner." (*Hist. Sketch*, 255.)

Gen. *Tetracharis* Grote, 1898.

Type: *T. cethura* Feld., sp.

Tetracharis cethura. PROC. AM. PHIL. SOC., xxxvii, Pl. i, Fig. 2 (neururation).

Radius four-branched; second radial branch arising before the cross-vein, although removed outwardly close to it. As this vein is shifting, it may be that this genus belongs on the other line as an antecedent, more generalized form to *Midea*. It is thus not an ideal link between *Euchloe* and *Pontia*, but it comes near to being one.

Gen. *Euchloe* Hübn., 1816.

Type: *E. cardamines*.

Euchloe cardamines. Mitt. a. d. Roemer Mus., 8 Taf. ii, Fig. 9 (neururation).

Radius five-branched; second radial in original position. This is the generalized form of the group, with the second radial branch not removed outwardly toward the cross-vein. Hence it may represent an ancestral form of *Pontia daphidice*, with *Tetracharis* as possibly marking an intermediate four-branched stage.

Euchloe stella.

Radius five-branched; second radial in original position. As compared with *cardamines* it agrees in essentials. It differs in that the fork *R*₄ is a little shorter and that there is a trace of a backward spur on the short and here not oblique cross-vein between *M*₂ and radius. Else I can find no difference and conclude the forms to be congeneric.

We now come to the lateral line, in which the second radial has shifted to the *Trifurcula* position, opposite the cross-vein and then beyond it. I reverse here the order and commence with the most generalized form, comparable with *Euchloe*.

Before going further I wish to say a word upon the humeral spur (precostal spur) of secondaries or its remnant. The truncated humeral spur rises oftenest at right angles. It is then not always easy to say which way it tends, yet it shows an inclination to curve either way in special cases. Whether we can lay a strong determinative value on the directions we now perceive is to me doubtful.

IN PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, January, 1899, I have suggested that the humeral spur is homologous with the shoulder veins of the Lachneidæ.

Gen. *Anthocharis* Boisd., 1836.

Type: *A. belemia*.

Anthocharis belemia.

Radius five-branched; second radial arising opposite cross-vein in the *Trifurcula* position. *R*₄ a short furcation. *M*₁ from radius about one-third the distance from cross-vein to external margin. Humeral spur of hind wings continuous, pointed, turned to base of wing. Apices of primaries hardly produced and costa but slightly produced; external margin straight; anal angle of secondaries determinate. This genus is an advance on the *Euchloe* type by the attainment of the cross-vein by *R*₂.

Anthocharis belia.

Quite similar to *belemia*; *R*₂ has progressed a little beyond cross-vein, hence more specialized than *belemia*. Shape of wing the same.

Anthocharis ausonides. PROC. AM. PHIL. SOC., xxxvii, Pl. i. Fig. 4 (neururation).

Quite similar to *belia*, again *R*₂ seems a trifle advanced; *R*₄ still shorter, so that this form is the more specialized of the three. Shape of wing identical.

Gen. *Zegris* Rambur, 1836.

Type: *Z. eupheme*.

Zegris eupheme.

Radius five-branched; second radial well removed to beyond cross-vein, thus abandoning and passing beyond the *Trifurcula* position, which is assumed by *Anthocharis*. *R*₁ takes up nearly the original position of *R*₂. The apical portion of the wing is produced, and here the branches *R*₃, *R*₄, *R*₅ with *M*₁ are brought together; *M*₁ having ascended the radius for nearly half the distance between cross-vein and apices. The costa is strongly depressed; external margin even; anal angle of secondaries more softened than usual.

In the position of *R*₂ this genus is more specialized than *Anthocharis* or *Trifurcula*, but it falls behind the latter in which the

radius is only four branched. I have elsewhere discussed the resemblance between *Trifurcula* and the present line.

Gen. *Midea* H.-S., 1867.

Type: *M. genutia*.

Midea genutia.

Radius four-branched, hence more specialized than *Anthocharis Zegris*, and with the second radial removed outwardly to very slightly beyond cross-vein, thus belonging to this series. Costa not depressed; apices acuminate between M_1 and M_2 ; external margin retired, sinuate; anal angle of secondaries hardly as prominent as in *Anthocharis*. M_1 ascends radius for a little more than one-third of the distance from cross-vein to external margin.

This genus differs from the equally four-branched *Tetracharis* in the passing of the cross-vein by R_2 as well as in the peculiar shaped primaries. I cannot admit the validity of the rule under which Mr. Scudder rejects this generic name. It is a limitation of the law of priority which is not recognized by all zoölogists, and is, I think, in itself indefensible.

I regret not to have had more species belonging to this group for examination. The series as arranged by me is not, as I have said, ideally perfect. It must be remembered that an existing type represents in some main feature a stage, standing between two others, which the higher genus has passed through and the lower commences to exhibit. After the type has been assumed, it will have further differentiated not only in the same direction, but, owing to the inequality of the specializations, in other directions which bring it out of focus. And the parent type has itself changed in the same way; perhaps we can even no longer recognize it as such, perhaps it has dropped away forever.

We now can turn to the generalized type of this series of "angled Whites," one which may stand for the parent of the two lines I have indicated and from the ancestors of which they may possibly have been thrown off. That we have to go to Chili for this type may possibly seem strange, and it may be there is a progenitor or its representative nearer home which I have not discovered, but the question of distribution is so far-reaching and so little is safely known as to its action and causes that I cannot here enter at all upon it. I must take the types where I find them.

Gen. *Eroessa* Doubleday, 1847.

Type: *E. chilensis*.

Eroessa chilensis.

Radius five-branched; second radial in original position above the cell. The first median branchlet has not ascended the radius, but is thrown off from the discal cross-vein. Hence this form is more generalized than all the preceding. It represents quite surely an ancestral form of *Euchloe*, in which latter M_1 ascends radius. Cells closed; second anal of fore wings sinuate; fork present. Humeral spur of hind wings abbreviate. Outer margin of wings uneven, slightly scalloped. The plan of neururation accords with the Anthocharid type. On the whole this is one of the most generalized Pierids I have met with.

In this group the humeral spur of secondaries is shortened and straight in all the forms examined except *Anthocharis belemia* and *A. ansonides*, in which it appears as if curved backwards to base of wing, and *Pontia daplidice*, in which it appears curved in the reverse direction, toward the apex of the wing, and this is the direction of *Pieris*, *Delias*, etc. This makes my reference of *Pontia* to this series doubtful. In any event, *daplidice* is the type of a distinct and more specialized genus than *Pieris*. It must be confessed that it is hardly possible to separate it neurationally from the *Mancipium* three-branched type. Alone the contour of the wing is Anthocharid; there is a slight sexual difference in the primaries, the male wing seeming a little narrower and the anal angle of hind wings is more determinate than in *Pieris*. The ornamentation is Anthocharid. I leave *Pontia* here to draw attention to it. It would, indeed, make the group here discussed more homogeneous were we to transfer *Pontia* to the typical Pierid series; the types would be more of a size. Again, in *Phulia*, the costal vein of hind wings is turned to base of wing, the Anthocharid direction, while in *Trifurcula* it is truncate or abbreviate, straight, as it is in many Anthocharids. In both genera the shape of the wings and ornamentation are Pierid rather than Anthocharid, but this is more clearly the case with *Phulia*.

The "Yellows."

There are apparently two lines, as indicated by me in PROC. AM. PHIL. SOC., January 1898, p. 38. In the non-typical line the wings are proportionately wide and frail, with less accentuated

angles, which, in a branch of the typical line, become unusually prominent, more so than in the angled Whites. No characters have been found to separate these lines, which possibly interlace. The antennæ seem relatively shorter, the thorax more pilose and the body stouter in the typical line, but these distinctions are relative and cannot be controlled.

Non-typical Yellows.

(Euremini.)

Gen. *Nathalis* Boisduval, 1836.

Type: *N. iole*.

Nathalis iole. Grote, PROC. AM. PHIL. SOC., xxxvii, Pl. i, Fig. 5 (neururation).

Wings entire; radius three-branched; R_1 in original position; R_2 advanced outwardly to extremely near cross-vein, hence the *Trifurcula* position is practically assumed. Discal cells on both wings broadening outwardly; M_1 ascending radius outside of discal cell for a space a little less than one-third of the distance to external margin. On fore wings M_2 is nearly central, on hind wings radial. A trace of fork to second anal on primaries. On secondaries the humeral spur has vanished, leaving the outer edge of the vein simply a little uneven or jagged. This is the most advanced form and a specialization of *Eurema*. In my figure, otherwise quite exact, the slightly jagged edge to subcostal is not, it hardly can be, rendered.

Gen. *Eurema* Hübner, 1816.

Type: *E. delia*.

Eurema delia.

Wings entire; radius four-branched; R_1 in original position; R_2 advanced, but much further from cross-vein than in *Nathalis*; R_3 a rather long furcation out of $R_4 + 5$. M_1 ascending radius but not so far as in *Nathalis*; M_2 nearly central on both wings. On secondaries the humeral spur has vanished leaving the vein apparently a trifle more jagged than in *Nathalis*. The cross-vein joins M_1 on hind wings, whereas in *Nathalis* it nearly meets, as on primaries, the radius.

If anything were needed to prove the reality of the successional movements in specialization of the veins on the butterfly's wing, as

brought out in my writings, a comparison of these two types would remove it. *Eurema* represents a stage which *Nathalis* has abandoned in all the above particulars.

Gen. *Terias* Swainson, 1820.

Type: *T. hecabe*.

Terias hecabe. Grote, PROC. AM. PHIL. SOC., Vol. xxxvii, Pl. i, Fig. 6 (neururation).

The wings are more ample, longer than in *Eurema*, but the neururation agrees so closely that I cannot precise any differences. It has seemed to me, by infinitesimal points, as less specialized; but it marks no new phase in the movements of the veins. The genus appears of very doubtful necessity and can be omitted from a table.

Gen. *Xanthidia* Boisduval, 1829.

Type: *X. nicippe*.

Xanthidia nicippe.

But if the necessity of *Terias* is doubtful, there seems too little for the retention of the present type, which agrees in the more ample wings with *Terias*. All the positions of the veins are maintained. I find only a slight variation in the discal cross-veins; on the hind wings of *Xanthidia* the latter run more obliquely outward superiorly, more continuously with *M*₂; on the fore wings, the inward bulging is slightly less pronounced. It seems a good deal like trifling to consider this a distinct genus and I can make no use of it. See Mr. Scudder's remark, *l. c.*, p. 288. I have been unable to secure a specimen of *Abæis cebrene* for comparison.

Gen. *Sphænogona* Butler, 1870.

Type: *S. bogotana*.

Sphænogona mexicana.

I have neither *bogotana*, which Mr. Kirby considers type, nor *ectriva*, so given by Mr. Scudder. Mr. Kirby writes that *bogotana* quite agrees with my species and I can readily believe it. The neururation is practically identical with that of *Eurema* or *Terias*; again the cross-vein of secondaries is a little less bulging, straighter. The only distinction upon which to found the use of a separate name, is that the hind wings are produced or angulate on external

margin, on the interspace just below *Cr*. Color and pattern are not distinctive, but virtually agree in all these forms.

The preceding types are all, except *Nathalis*, too closely allied to be generic, and they all agree in one important point, the reduction of the humeral spur. The marks of a former presence of the spur are to be seen on the shoulder of the subcostal vein, slight, jagged protuberances. These are so obscure and so similar in all the cases, that it is hardly possible to draw any distinction, and my impression, that they are less noticeable in *Nathalis*, may be after all incorrect. But it is of no obvious importance; the main fact being that the spur has vanished in all these types. That *Eurema*, *Terias*, *Xanthidia* and *Sphænogona* should agree in this is not extraordinary, since the neururation is otherwise so similar in all these forms, that their generic separation seems quite unnecessary. Nor are there any other characters, so far as I am able to see, which would authorize us to consider them as types of different genera, and only in *Sphænogona* have we the angulation of external margin of secondaries to sustain a separate title. But that *Nathalis* should not differ, leads to the inference that the reduction of the radial branches may have happened after the loss of the humeral spur. The disappearance of the branchlet suddenly, however, is contradicted by the mass of instances in which the evidence is clear, that the absorption takes place slowly. The stages of progression of the branches along the radius are constantly marked in a variety of forms, in which we find them but slightly differing in relative position. And when *R*₂ finally leaves its original place above the cell, where *R*₁ remains, the inference is plainly that it gradually moves along toward the tip of the wing. We see it in fact advancing by consecutive stages to the cross-vein, there assuming the *Trifurcula* position, and then, traveling still onward, gradually approaching the apices of the primaries. All this shifting, which we can now follow, by studying the different stages in different types, must be assumed to reflect the action which has formerly exhausted itself on the radius of secondaries, and of which only fragmentary direct evidence remains in the five-branched radius of *Hepialus*, the Micropterygides, and a late stage of reduction in *Crinopteryx familiella*. After all admissions, that in certain cases the present reduction on the primaries may be relatively rapid, the very multiplicity of the existing stages is evidence that in general it is being slowly accomplished. The movement has been going on

since butterflies were butterflies, whose story is forever in the changes of their wings.

The following two genera represent generalized types as compared with the preceding, *R*₂ being in original position.

Gen. *Ixias* Hübner, 1816.

Type: *I. pyrene*.

Ixias pyrene.

Radius four-branched; *R*₁ and *R*₂ arising above cell; *R*₃ a moderate fork out of *R*₄ + 5. Discal cell closed. *M*₁ ascending radius for a short distance beyond cross-vein; *M*₂ radial. Second anal sinuate with a strong fork at base. • Hind wings with humeral spur pointed, turned to apex of wing; lower portion of discal cross-vein weaker, joining *M*₂, which appears continuous.

More specialized than the allied *Idmais* and *Teracolus* by *M*₁ being further removed from cross-vein out of radius. The genus may not be correctly placed, but would fall in here from the stage of specialization.

Gen. *Eronia* Hübner, 1822.

Type: *E. cleodora*.

Eronia cleodora.

Radius five-branched; *R*₁ and *R*₂ in original position above cell; *R*₃, 4 and 5 near together before apices. Discal cell closed; *M*₁ not ascending radius, but leaving at upper angle of cell. Hind wings with humeral spur pointed, turning to apex of wing; discal cross-vein joining *M*₂.

I have little doubt that this generalized type with five-branched radius represents an ancestral phase of *Eurema* and allies.

Typical "Yellows."

(Eurymini.)

As formerly pointed out by me, there seem to be two terminal lines, which appear to fuse and are probably also connected with the Euremini.

Gen. *Eurymus* Swainson, 1829.

Type: *E. hyale*.

Eurymus hyale. Mitt. a. d. Roem. Mus., 8, Taf. ii, Fig. 7 (nuration).

Radius four-branched; *R*₂ has abandoned its original position and advanced along radius to considerably beyond cross-vein.

Discal cell closed; M_1 has ascended radius for nearly a third of the distance between cross-vein and external margin; M_2 strongly radial. On hind wings the humeral spur has entirely vanished and seems to have left no traces; M_2 from cross-vein.

This is a specialized form from the above characters. Its ally, *E. edusa*, is figured PROC. AMER. PHILOS. SOC., xxxvii, Pl. ii, Fig. 8, and the neururation discussed. This genus is known in literature as *Colias*; I follow Mr. Scudder in retaining *Colias* for the type *C. rhamni*.

Gen. *Zerene* Hübner, 1816.

Type: *Z. cæsonia*.

= *Meganostoma* Reakirt, 1863.

Zerene cæsonia. PROC. AMER. PHILOS. SOC., xxxvii, Pl. ii, Fig. 9 (neururation).

This type can be used as representing a close antecedent stage of *Eurymus*, one through which *Eurymus* has passed. The dog's head pattern is then a generalization of the pattern of *Eurymus*, and this would be borne out by *Idmais*, in which it is yet more developed and which represents a still earlier phase of these two genera. The second radial branch stops at the cross-vein in *Zerene*, assuming the *Trifurcula* position. On hind wings a fragment of the humeral spur remains, the tip being worn away.

I formerly referred *Zerene* as = *Colias* Auct. nec Fab., which seems to have been indeed Hübner's intention, who, however, also included this type (*cæsonia*). Mr. Scudder has corrected me (*Historical Sketch*, 213).

The preceding types show R_2 in a state of flux. In the following it retains its original position above the cell and the types are accordingly more generalized. I have my doubts whether a linear succession here displays their true affinities, but they are at least correctly placed with regard to the degree of specialization of the wings.

Gen. *Teracolus* Swainson, 1832.

Type: *T. subfasciatus*.

Teracolus subfasciatus.

Primaries with sharp apices; radius four-branched; R_1 and R_2 in original position above cell; R_3 a moderate furcation out of $R_4 + 5$ to tip of wing. Discal cell closed; M_1 out of radius just

beyond upper angle of the cell. Second anal with distinct fork at base. Hind wings with humeral spur pointed, turning toward apices.

This genus is generalized by the fact that M_1 has not ascended radius for any distance beyond cross-vein, and that R_2 is in original position. It agrees in these characters with the following. It is peculiar by the sharp apices. On both wings the discal cross-vein between M_2 and M_3 is somewhat weakened and M_2 appears continuous in consequence. I can see no indication that the genus is Anthocharid, as assumed by Reuter.

Gen. *Idmais* Boisduval, 1836.

Type: *I. chrysonome*.

Idmais vesta.

I have been unable to obtain the type. The present species shows a form quite agreeing with *Teracolus*, differing only that the lower part of the cross-vein on secondaries joins the point where M_1 and M_2 furcate; this position of the cross-vein in *Teracolus* joins M_2 beyond the furcation. Hind wings with humeral spur as in *Teracolus*. Both these genera are more generalized than *Eurymus* (*Colias*) by the well-developed humeral spur, the second radial not advanced, M_1 not ascending radius. They may thus be regarded as ancestral types of *Eurymus*.

This genus may be regarded as more specialized than *Teracolus*, on account of the disposition of the discal cross-vein.

We may now turn to the line in which the wings are angulated and of an unusual, somewhat leaflike shape, in which the agency of mimicry has been suspected.

Gen. *Colias* Fabricius, 1807.

Type: *C. rhamni*.

Colias rhamni. Mitt. a. d. Roem. Mus., 8, Taf. ii, Fig. 8 (neuration).

The costal region above the cell is wider than usual and the subcostal and radial branches are somewhat bent upwards to sustain it. Radius four-branched; R_1 and R_2 apparently in original position above the cell, a little further apart than usual. M_1 ascends radius for but a brief space; M_2 radial. Second anal with a strong fork at base. Hind wings with humeral spur vanished; dis-

cal cross-vein medially degenerate, joining M_2 immediately beyond the furcation of M_2 with M_3 . This species, with sickle-shaped outer margin of primaries and pointed apices between $R_4 + 5$ and M_1 , with also angulate secondaries at C_1 , is more specialized than *Rhodocera*, and lags behind *Amynthia* in the position of R_2 . Since I use the type for comparison I describe it first; on the whole it seems the more specialized genus.

The generic terms *Gonepteryx* Leach, 1815, and *Earina* Speyer, 1839, are considered by Mr. Scudder as synonymous with *Colias* Fab., nec Auct., as also *Gonoptera* Dalman, in Billberg, 1820.

Gen. *Amynthia* Swainson, 1832.

Type: *A. mæricula*.

Amynthia mæricula.

This type shows a stage in which R_2 has progressed further along radius than in *Colias*, stopping but little before cross-vein. On the other hand there are jagged points showing the trace of the humeral spur, which I do not see in *Colias*, and the position of M_2 on secondaries is more central from cross-vein and more generalized, being as in *Rhodocera*. The specializations are, as I have constantly stated, unequal. The apices of fore wings are less sharp in *Amynthia*, which, aside from the movement of R_2 , is more generalized than *Colias*.

Gen. *Rhodocera* Boisduval, 1829.

Type: *R. menippe*.

Rhodocera menippe.

This form differs from the preceding in the absence of angulation to hind wings and the blunt primaries, with external margin, but little depressed. It is the more primitive of the three forms, agreeing with *Amynthia* in the position of M_2 and approaching *Colias* in the position of R_2 . It is more generalized than either in the fact that the base of the humeral spur still remains. This large butterfly represents a stage which both *Colias* and *Amynthia* have, in varying degrees, abandoned.

We will now take up an angulate type, which is more specialized than *Rhodocera*, which it resembles in shape of primaries, and intermediate between *Colias* and *Amynthia* in position of M_2 .

Gen. *Dercas* Boisduval, 1847.

Type : *D. verhuellii*.

Dercas verhuellii.

Primaries blunt, external margin uneven ; not depressed ; secondaries angulated just beyond M_3 . Texture of the wings frail as compared with *Colias* and allies. Radius four-branched ; R_2 has advanced to almost exactly opposite cross-vein, thus the *Trifurcular* position is very nearly assumed. Else the venation is much as in *Amynthia*, M_2 a little more radial. Hind wings, with humeral spur developed, but feeble, pointed, curving a little to base of wing.

This form has evidently the same parentage as the preceding, but represents a slightly differing type of wing.

We now arrive at three types, which are really too close to be of much interest to the classification, and which stand in the relation of ancestral forms to the foregoing modified types with angulate, leaf-shaped wings. I take the genera in the order of priority.

Gen. *Catopsilia* Hübner, 1816.

Type : *C. crocale*.

Catopsilia crocale.

Wings entire ; radius four-branched ; R_2 advanced almost to opposite cross-vein, not quite so near as in *Dercas*. Discal cell closed ; M_1 from radius, about as far advanced along the vein as in preceding genera ; M_2 from cross-vein, radial, nearly in the position of preceding genera. Second anal with fork at base. The humeral spur is present as a basal fragment.

This series shows the progression of M_1 up the radius, in *Catopsilia* the most advanced. The genera on the whole lag behind the preceding, not only in the non-angulate, normally shaped wings, but as affording evidence that the *Colias* types have sprung from such forms in the retarded characters of the venation.

Gen. *Phæbis* Hübner, 1816.

Type : *P. argante*.

Phæbis argante.

As compared with *Catopsilia* the ascent of M_1 up the radius is retarded ; the fork of R_3 with $R_4 + 5$ is somewhat longer, all characters of comparative generalization. In fact these three types

only represent unequal stages in the normal course of specialization, preserving an identity of general character which renders the idea of different genera difficult. It must be also borne in mind that all the species have not been compared, and the chances seem to be that among a number of forms agreeing so well externally, similar characters to those here used will occur, still further increasing the number of genera.

In the comparative length of the fork R_3 with $R_4 + 5$ the genus *Catopsilia* is the more specialized.

Gen. *Callidryas* Boisduval and Le Conte, 1829.

Type: *C. eubule*.

Callidryas eubule. PROC. AM. PHIL. SOC., Vol. xxxvii, Pl. ii, Fig. 10 (neurulation).

R_2 has strayed still further from cross-vein than in the two preceding types. The fork of R_3 with $R_4 + 5$ is much as in *Phæbis*; on the other hand M_1 has progressed further up the vein, intermediate in position between *Catopsilia* and *Phæbis*. Perhaps this type is really intermediate, although the view that it is the more generalized is tenable. The base of the humeral spur is developed as in *Phæbis*, which latter may more nearly represent the type from which the others and the whole Eurymini have sprung.

We now come to what appears to be a lateral specialization of *Catopsilia* or *Phæbis*.

Gen. *Parura* Kirby, 1896.

Type: *P. cipris* Fab. nec Cramer.

= *Metura* Butler, 1873, preoccupied.

Parura cipris.

Differs from the types included under *Catopsilia* by the hind wings being strongly produced at anal angle. The condition of the shifting branches nearly reproduces the condition of *Phæbis*. The humeral spur is incomplete.

I have now exhausted my material of the types of genera in the Pierids. It has been sufficiently extensive, I hope, to have allowed me to sketch the group and to lay down for the first time some safe conclusions upon the neurulation. That more remains to be done I am fully aware, nor do I insist upon minor points, liable to be modified from greater material. I have wished mainly to supply a neurational basis for the generic types examined and as a general rule

have abstained from interfering in the question of the necessity for generic titles.

MOVEMENT OF THE VEINS IN THE WINGS OF THE PIERIDIDÆ.

The movable veins of the primary wing are the branchlets of the radius and media. The generalized type has five branchlets to the radius, two arising above the discal cell, the remainder beyond the cross-vein. The diminution by specialization of the branchlets is effected by their outward movement, and they appear to pass off by the external margin of the wing. It is especially the movement of the second radial branchlet which gives rise to interesting combinations. Sometimes the outer branchlets disappear, leaving a single vein, and the second radial remains still in position, as in *Pontia*. Again the second radial commences its travels along the upper side of the vein, stopping at various points along the route, before the terminal branchlets have been disposed of, as in *Anthocharis*. Arrived at the point opposite the cross-vein, it gives the *Trifurcula* position, as I have called it in this paper, in which the second radial, then the main vein of the radius from which it ascends, and finally the cross-vein, running in an opposed downward direction, meeting, give the appearance of a trident. This position of R_2 is not confined to *Trifurcula*; it always recurs and must recur in the progress of the second radial branchlet along the vein, and in fact is exhibited now by a number of genera. Also in genera, like *Piccarda*, *Delias*, *Perrhybris*, in which the second radial has long passed the cross-vein by, the ancestors must have exhibited the *Trifurcula* position at some time in their history, when their second radial branchlet attained this point, and for the moment retained it. In the Pierididæ the first radial always keeps its position above the cell.

The generalized type, so far as the media is concerned, has the three branchlets all springing from the cross-vein, the second medial having a central position. This is soon abandoned in specialization and the branchlet approaches the radius, while the cross-vein, in the widening space between M_2 and M_3 , become somewhat worn, the first sign of the ultimate breaking up of the median system through the opening of the discal cell. In the meantime the first median branchlet leaves the cross-vein and ascends the radius on its lower side. Only in such extreme cases of specialization as

Phulia and *Pseudopontia* does the second median branchlet follow this example. Meanwhile the third median attaches itself to the cubital system. In the Pierididæ, the movement, by which the median system seeks its extirpation, is arrested at this point; the cell never completely opening, although often degenerate, between M_2 and M_3 , as in certain *Nymphalinæ*, in which, *per contra*, the upper two branchlets of the media never leave the cross-vein, crowding themselves into the upper corner, but refusing to ascend the radius. This is the general attitude of the brush-footed butterflies. The opening of the cell, wherever this happens by the disappearance of the cross-vein centrally, is the signal that the median system has finally departed; the radial and cubital systems of the wing inheriting its last possessions, the three terminal branchlets which they divide between them and subsequently have to feed. The base of the media had departed long ago; the veins running from the cross-vein to the root of the wing are now only found in the Tineides, although scars along the tegument of the cell and little backward jutting spurs on the cross-vein tell of their former existence in the Pierids as well. The movements of the veins belonging to the two systems are unequal.

The hind wings seem to show little movement of the veins; they have performed an antecedent work in the simplification of the radius, which shows as a single vein. The first radial branch has seemingly gone to make up the humeral cell, but in the Pierids, the humeral cell has itself become absorbed and all traces of the forking of the radius at base have vanished. I therefore notate the radius by a simple R ; theoretically it should stand $R_2 + 3 + 4 + 5$, while the subcostal vein should stand $Sc. + R_1$, marking where the radial branchlets have respectively disappeared to. The hind wings of the Nymphalids show a greater movement of the veins than those of the Pierids; in the brush-footed butterflies the disintegration of the median series seems here to find its impulse and the specialization of the hind wings is in a constant state of advance. This is seen by the opening of the cell on the secondaries of *Araschnia*, *Melitæa*, etc., while the cell on primaries remains still more or less perfectly closed. Evolution is more active with the fore wings of the Pierids, with the hind wings of the Nymphalids; in which latter the bunching of the median nervules at the upper corner of the cell seems to meet the requirements of their mode of flight.

VALUE OF GENERIC CHARACTERS.

This study of the wings of the Pierids will, I think, demonstrate that there exists no standard by which we can decide what constitutes or how much character should underlie the idea of a genus. The difference between the genus and species idea is quantitative merely. The conception of a genus as an independent entity, as in itself a thing closed and with real outlines and bounds, which it only requires a trained understanding to recognize, is seen to be illusory. The apparent limits of the genera are due, like those of the species, to gaps in the record. When these gaps are slight the lumpers ignore them, forgetting that the main business of entomology is to exhibit differences, not to lay stress on resemblances. The needless erection of genera should, indeed, be avoided, no less than the overlooking of distinctive characters. But what is here "needless?" One can only illustrate what one subjectively considers needless by examples. The generic term *Xanthidia* seems to me quite unnecessary. On the other hand, I would retain the Anthocharid genera, although superficially much alike, because they emphasize certain stages in the specialization of the radius, which we are obliged to notice and discuss. *Tetracharis*, for instance, represents a four-branched type in which R_2 has not yet attained the *Trifurcula* position; as such it is as much entitled to a generic name as another form not yet recognized as a member of a chain in which the links are so continuous. Everywhere, however, the links exist or have existed. It is not only that it is improbable that Nature has here progressed by jumps, but we cannot draw the line anywhere with exactness between such jumps as shall, and such as shall *not* be entitled to generic recognition. It becomes thus a subjective question, to be settled by each observer, accordingly as he is soberly or extravagantly inclined in either direction, as to making many or making few genera. I myself tend in the direction of making many, for fear of passing over characters of structure and to avoid packing away distinct types of succession in one category. It becomes, finally, clearer, that many more kinds of butterflies have perished than are now to be seen; the tertiary and quaternary faunæ seem specifically different.

Certain of the characters of neuration here recognized as of generic value, so far as regards the movable veins or branchlets, are apt to appear as characters of variation within the limits of the same species of butterfly, although I have not noticed any variation of

the kind in the Pierids. In the Parnassiidæ I have recorded an individual variation in the position of R_2 and M_1 on the fore wings of *Zerynthia*. The fact that these variations take the normal direction, seems to denote, that they are shown by anticipation (specialization) by a part of the mass of individuals before becoming fixed for the species as a whole. I have found no sexual characters in the neururation; these appear to be limited to the outline of the wings. In the male, *e. g.*, *Tachyris*, the primaries are in special cases narrowed and more pointed at the tips; in *Dismorphia* there is added to this narrowness in the primaries a compensatory greater breadth in the secondary wings. The female wing has been preferred for study, since this sex seems the more conservative. I have, however, found no positive proof of this in the neururation, so far as the limited number of specimens studied will allow me to see. The neururation affords no assistance to the theory that the color and pattern of the female is influenced by atavism. In fact, I have not succeeded in showing that the color and veining move together at all closely, and have accordingly omitted almost everything not related to structure and shape of the wings. As with the Papilionides, however, a white color, while persistent throughout a line, seems to be at least a secondary, not a primary color. The male, *e. g.*, *Perrhybris*, *Prioneris*, *Phrissura*, *Huphina*, is apt to whiten, to become paler.

But in *Enantia melite* and in *Colias rhamni* the male is of a much deeper color, more yellow than the female, while the most specialized and the most generalized forms alike show pale colors in the Pierididæ. In size the butterflies seem to tend to becoming smaller, as seen in such specialized forms as *Phulia* and *Nathalis*.

The total impression we derive of the neururation is one of continuity. The forms lead from one to another with unequal gaps between the genera, hence the generic characters are unequal also. The changes in the position of the veins are no doubt mechanically caused by the strain of the organism against its media. The disparities are accentuated for the moment, related to those interferences in the world process which are the ultimate cause of all diversity in nature.

GENEALOGICAL TREES AND TABLES.

In proportion as an intelligible system underlies the drawing up of genealogical trees and tables of genera are they of use and

value. As I once said of the subgenera of *Apatela*, they serve to light up the subject from within. There exist genealogical twigs scattered up and down in literature which seem to me to have been drawn at haphazard, so little or no explanation is vouchsafed, and, on examination, so little system is displayed. But from Mr. Scudder's dangerous-looking cluster of spikes to the peaceful gulf stream of names which flows over Mr. Reuter's double page, the lines can be followed with the help of a pin, and one feels that the opportunity is offered for pleasantly acquiring exclusive information. It is, however, when I survey Sir George Hampson's phylogeny of the Syntomidæ, that the magnitude of the task before me, in preparing a similar table of the Pierid genera, becomes appalling. There are so many, many, a perfect trellis work of names, all bound together by short and sharp lines of descent and affinity. There are no doubts, no uncertainties; each title finds its exact place, as in a Chinese puzzle, which, if it were to fall apart, who could put together again? And when I look up the couple of names I have contributed to this ordered espalier, I am obliged to confess that never, never would I have been able to get them into their present situation. And there is no key to the puzzle, no showing how it is done. Why are *Metarctia*, *Pseudapiconoma*, *Zethes*, so placed? Why is *Hyaleucerea* at the bottom and *Urolasia* at the top? Why all the names between them? Why? Why? "*Pourquoy*, my dear knight?" As in the play, the question may be impatiently answered by another—"Do, or not do?" The idea of a genealogical tree being given, the lines must be drawn in every case, to give an idea of completeness, of mastery of the subject, and this seems rather to be Mr. Meyrick's conception and definition of Darwinism.

And yet these relationships, to be symbolized by these equal lines, are always unequally expressed and often in nature very obscurely indicated. The leading structural peculiarity of a large group once seized, it is not difficult to detect this distinguishing feature when it occurs in a second, otherwise differing group, to infer thereupon the phyletic connection, assign the respective grade of specialization and conclude by uniting the collective names by a line in a diagram. With genera, when numerous, the question becomes one of greater detail, the interrelations grow complicated; so that, if one insists upon drawing up a complete table and connecting all the names, the temptation in certain places to cut a Gordian knot by tying one becomes correspondingly frequent.

Despite, then, the preconception of authors, that their papers on their subject are final, yet it is seen that they are not so, and this from the complexity of the matter and the inability of the writer to look all around it. It was Dr. Johnson who said that the first care of the builder of a new system is to demolish the fabrics which are standing. I am afraid this may be repeated of some of our work on the Lepidoptera, and that this demolition is not always necessary. I should be sorry, however, to apply here the Doctor's further opinion that thus the human mind is kept in motion without progress. At the end of the last century there seems to me to be a clear residue of advance. The truth of evolution conceded, the great fact that the biological is part of the geological process admitted, it might seem superfluous to attempt to gauge the flight of butterflies, were they not fellow-passengers across the scene, and could we not detect in their fate the shadow of our own. No witness can be thought unnecessary whose testimony, even if silent, bears on the problem of life. Undoubtedly in this way our interest in the contents of Natural History Museums increases the more we consider them in relation to ourselves. Indeed, this is the deeper reason for the existence of all collections.

To return to our tables of genera: it is but too certain I can offer no such complete scheme of the Pierids as Sir George Hampson has given us of the Syntomids. Setting aside the incompleteness of my material, I do not know if *Pontia*, for instance, is surely an Anthocharid, or belongs to the typical line of *Pieris*. I do not even know if there is anybody who could tell me, so contradictory appears the evidence, and there are a number of questions, perhaps less crucial and more easily satisfactorily solved, as to which I am in doubt, and to resolve my doubts by drawing firm lines on a plan I am incapable. By a hundred points do these frail insects impinge on their surroundings and fade away into space. All that I can try to do is to see that the names along a horizontal line represent forms conforming, barring immeasurable inequalities, to a certain approximate grade of specialization, while those, in the same vertical line, succeed one another in the expression of one of the movements which I have elsewhere shown to occur in the position and number of the veins of the wing. Thus the succession represents ideally the probable or possible sequence in time and space. I use generic names only in connection with the structure of the type.

THE DIPHYLETISM OF THE DIURNALS.

From unpublished photographs sent me by Prof. Comstock it appears that on primaries a bifurcate third anal vein is present in the pupa of *Pieris*, of which no trace is seen in the imago, unless we consider the thin piece, anastomosing with second anal at base, as a relic. If the homology of the free third anal vein of the imago of the Papilionides, with this thin piece (sometimes a mere scar, again wanting) joined outwardly to second anal of the imago of the Hesperides, be denied, the definition given by me (PROC. AMER. PHIL. SOC., xxxviii, 43) may be accepted. If, on the contrary, the homology be asserted, then the wording may be altered as follows :

- A. Butterflies having a short third anal vein on primaries, running downwardly free from base of wing to internal margin ; on secondaries only one anal vein. PAPILIONIDES.
- B. Butterflies having a short third anal vein on primaries, joining outwardly the second anal vein (this fork sometimes wanting by reduction and always thinner than second anal or degenerate) and having more than one anal vein on secondaries HESPERIADES.

The question of the homology of the veins cannot affect (as I have elsewhere stated) the argument as to the diphyletism of the diurnals. A natural group in which a certain vein is free in the imago cannot well have the same origin with an opposed and equally natural group in which this same vein runs in an opposite direction and fuses with the next vein lying above it. The troublesome factor in the classification of the diurnals has been the position of the Papilionides. They have been approached violently to the Pierids and learned treatises have allied them with the Hesperids. And then they have been forcibly thrust in between the Blues and the Skippers, an inoculation which the genealogical tree most naturally resists. If we succeed in removing them from their enforced union with the Hesperides, unexpected light may fall upon the history of the development of the Lepidopterous organization. Nor can we fit the Papilionides in between the Hesperides and the moths, so that, in a linear arrangement, the only course remaining open for us to pursue is to head with them the series of the diurnals. The whole question of phylogeny is a relative one. Even if we can make out resemblances in

the embryonal wing, these do not abrogate the differences in the imaginal. These exist in the present instance, throwing the common origin of the two groups further back, and render the supposition tenable, that the Papilionides and Hesperiadæ, as butterflies, have a different origin. The conclusion to which I have come is this, that all the groups of the Hesperiadæ converge in ancestral types of the Skippers, to the entire exclusion of the Papilionides.

Objections will be made that the Skippers are so different from other butterflies. I have tried to show that these differences arise from secondary specializations and are not constant or peculiar. From a bend in the antennæ, classifiers give such names as "Grypocera." But how about those Skippers which lack the bend? Are these, too, "Grypocera"? Again, some writers dwell with astonishment upon the fact that certain Skippers like to stroll in the dusk of evening, and these writers hold that, with such habits, these Skippers cannot be considered as orthodox diurnals. And then a special name is coined for them as a sort of atonement for heresy. But clearly all this arises from preconceived opinions, from want of consideration and weighing of characters. No value is given by these classifiers to the exceptions which deprive their categories of proper support. All the characters shown by the Skippers are explainable by the fact that we have to do with a group originally transitional in habit and structure, and having become a fixed and natural one through custom.

THE EVIDENCE FROM FOSSIL BUTTERFLIES.

The evidence from paleontology is so scant that of itself it can have no deciding weight. One feature, however, which assists my ideas is that the tertiary deposits have yielded a larger proportion of Nymphalids. We might naturally expect, among the Hesperiadæ, that the groups in which the radius is specialized, viz., the Pierids and the Blues, would be more recent, succeeding in point of time the Skippers and the Nymphalids. I think we may assume the fact. In a recent valuable paper by Dr. Rebel, a restoration is given of the wing of *Lycænites*. This is a presumed lycænid, and there is no improbability in the view that the Blues may have been represented in the Miocene. But I wish to point out that a slight change in the restored wing parts would give us the Skipper type, in this case apparently one resembling the North American Megathymidæ, a group with generalized larvæ, and which may also have enjoyed a greater range and rep-

resentation in tertiary than in recent time. For the Miocene strata of central Europe contain a number of types of vertebrates and land shells which are now confined to America, but at that epoch enjoyed so wide a distribution. In Europe these types subsequently disappeared, giving place to more specialized types, but in America they have persisted. Without having seen the specimen I could not venture upon an opinion not in accord with that of so reliable an observer, and what I now point out is that the wings of the Blues and Skippers nearly agree, and I repeat that it is probable that the former group has emerged from the same immediate stock with the latter. Another circumstance to be noted is that the tertiary species are generally distinct. This leaves room for the supposition that the diurnals have changed both a good deal and comparatively rapidly. It seems that the Nymphalids flourished in the tertiary and that the quaternary is evidently the epoch of the Pierids and the Blues, so that we may safely regard these latter groups as among the more modern types of butterflies.

With regard to the phylogenetic line *A*, the Papilionides, we know, from Dr. Rebel's researches, that its most advanced group, the Parnassians, existed in the Miocene. No certain identification of fossil remains of the Swallowtails proper, the Papilionidæ, appears to have been yet made anywhere. But if my views are correct, we may yet discover that Ornithoptera-like forms had a wider distribution in preceding epochs than at the present time. The classification and the general theory of the development of the diurnals, brought forward in this present and previous communications to the American Philosophical Society, is so different from the general opinions and conclusions of other authors, that I have given them with diffidence and in all deference. My views have gradually shaped themselves out of the discovery of the directions of the movements which undoubtedly occur in the evolution of the veining of the Lepidopterous wing. While I have tried to correlate the subordinate types, I have endeavored to make it quite clear that there are two antagonistic and principal types in the neururation of the diurnals, and that this fact authorizes the belief that the Papilionides and Hesperiaes may have had an independent origin.

MIMICRY.

None of my predecessors appear to have studied the phenomena of mimicry in connection with the structure and specialization of

(Pierini)

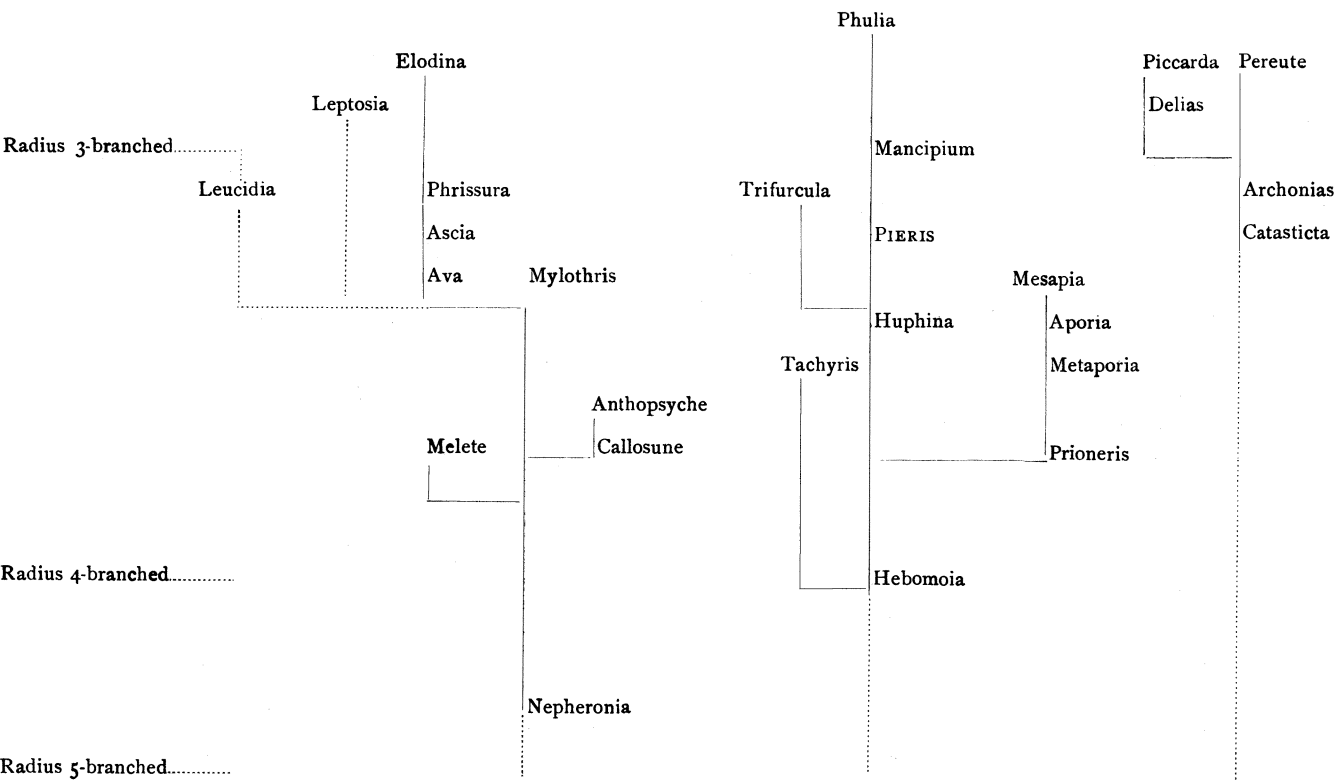
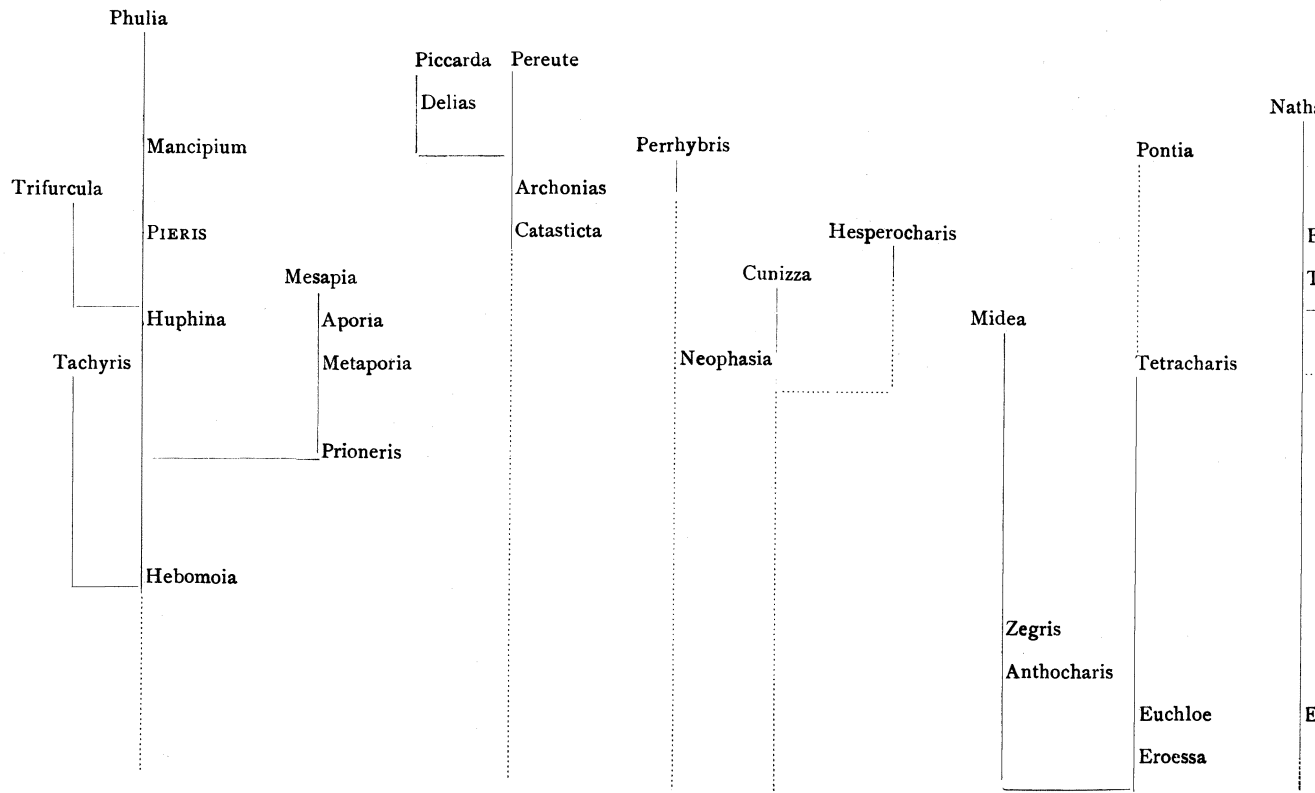


TABLE OF GENERA OF PIERIDIDÆ.

(Pierini)

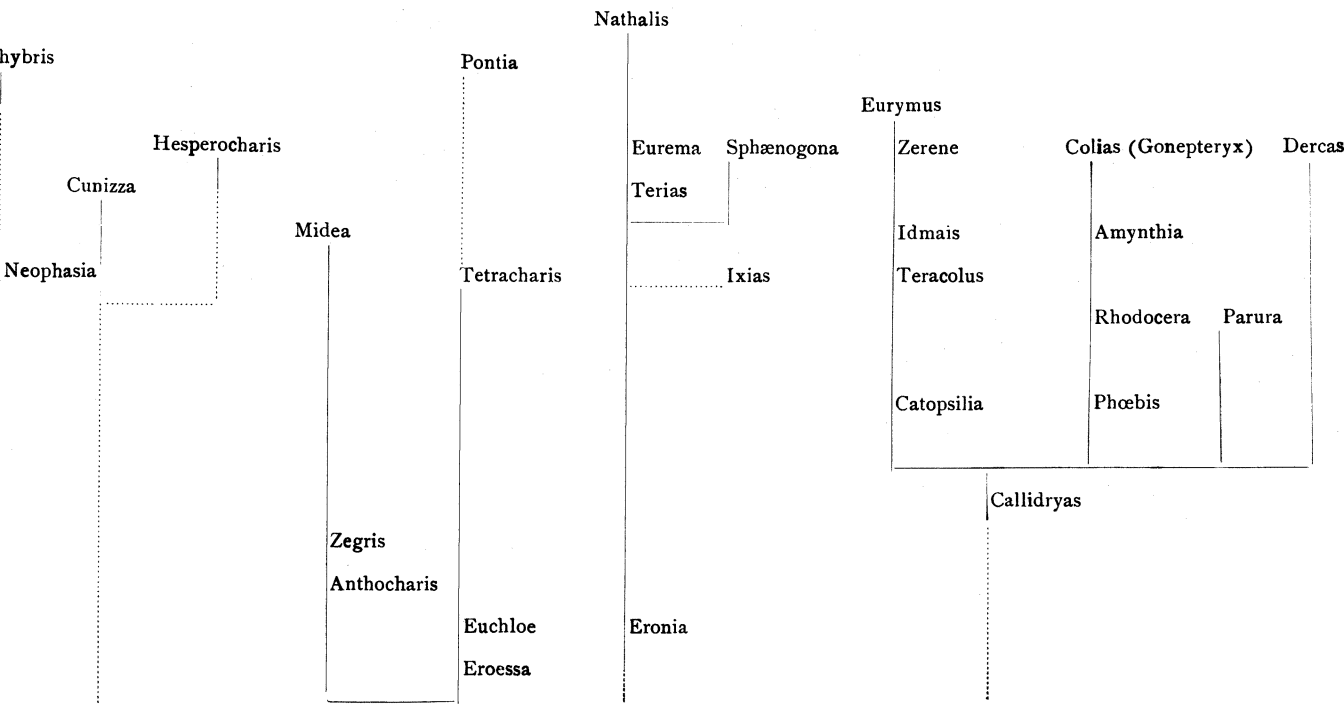
(Anthocharini)



(Anthocharini)

(Euremini)

(Eurymini)



the wings. It has been with them a question chiefly of color and pattern or outline. The conclusion to which these studies of the neururation lead is this: *The older and more generalized forms, here Nymphalids and Papilionids, serve as models; the younger and more specialized forms, here Pierids and Dismorphians, do the copying.* As yet I know of no older type which has assumed the dress of a younger. Mimicry would thus fall in with other phenomena of succession, and is deprived of the appearance of fortuity which now clings to it in literature.

SYSTEM OF NOTATION.

In the designation of the veins I have followed here the same system as in my other papers, with the exception that I have adopted Prof. Comstock's recent change with regard to the longitudinal veins. These are indicated by an initial letter of the name instead of a Roman numeral. On the fore wings the subcostal is marked *S*; the radius by *R*, with the Arabic numerals 1 to 5 for the branches; the Media by *M*1 to 3; the Cubitus by *C*1 to 2; the anal veins by *A*1 to 3; the third anal is wanting in the Hesperiadæ, unless the more or less illegible straight prong from the second anal at base be homologous with it. The costal vein is absent by reduction on both wings; on the primaries the thickening of the costal edge may or may not be a trace of it, and in any event is of no importance to designate. On the hind wings I have suggested (January, '99) that the so-called "precostal spur" is homologous with the "humeral veins" of Prof. Comstock, multiplied in the Lachneids. In a letter to me Prof. Comstock adopts this view and suggests the prong should be so notated. I prefer to call it the "humeral spur" and to mark it "h. s."; the word "vein" might cause a confusion with a longitudinal vein. The subcostal of the hind wings has absorbed apparently, Prof. Comstock tells me, the first branch of the radius as part of the humeral cell. Since this is obsolete in the present group, I have marked the vein here as on the primaries with a simple *S*. The radius of hind wings is reduced to a single vein, representing $R_2 + 3 + 4 + 5$, the branch *R*1 having gone apparently with the subcostal; but, since this cannot be seen in the present group, there is no use in complicating the notation and I use merely the letter *R*. The other veins are as on fore wings. The persistent anal vein is the

second ; the first is also the first to disappear, followed by the fourth and third.

The humeral spurs of the Lachneidæ have been cited as examples of specialization by addition in the wings of the Lepidoptera. This may have been their origin. They appear to attain their maximal development on the secondaries of *Eutricha quercifolia* (consult Grote, *Ill. Zeits. f. Entom.*, Band 4, Heft 4, Fig. 1). In the diurnals the spurs would be already reduced to a single one. But even in the Lachneids the generic types I have examined have them very unequally developed. And they may have appeared independently in different groups. The repetition of the neururation, as might be expected in homodynamic organs like the wings, is, so far as I know, always exact. Slight variational changes in the position of the veins, following the general directions of specialization, are repeated on both sides of the insect. Accidental aberrations, failures in development, are of unequal, local origin and have a special cause. The two classes of individual deviation from a given type should be discriminated.

The bending inwardly of *A* 3 on the secondaries of *Elodina egnatia* (Fig. 10) leaves a wide, unsupported lobe at the base of the wing, which seems to be traversed by an irregular, linear thickening of the membrane, having the false appearance of a vein. This would be secondary and its origin analogous with that of the humeral spurs. But the feature must be studied from more material than at the moment is at my disposal. It is possible that the last anal vein (*A* 4) in *Pseudopontia*, marked in my figure "ix," is homologous with this thickening in *Elodina*; in both *A* 3 is bent inwardly. Compare these PROCEEDINGS, xxxvii, No. 157, Pl. i, Fig. 7.

ACKNOWLEDGMENTS.

After wandering for nearly forty years in the wilderness of butterflies, it may be the last time I have the opportunity of expressing my indebtedness to other students and their works. And first I return thanks to Prof. Comstock for the assistance which his publications on the wings of the Lepidoptera have been to me, no less than for his kind communications upon debatable points. Prof. Comstock has worked out, with immense patience and labor, a system of notation applicable to the veins of all insect wings, and which is here adopted for the butterflies. Thus the original idea of Redtenbacher, who must not be forgotten, has, I hope, received its

practical realization. Nor should the work of Herrick-Schaeffer upon the veining, even if partial and exclusive, be passed over. This author was the true successor of Hübner, who troubled himself alone with color and pattern and shape, not going beneath the surface of the wings. If I mention again Mr. Scudder's *Historical Sketch*, it is to renew the expression of my hope that the book may be republished and brought down to date. No one can do this so well as the gifted and industrious author whose acquaintance I have enjoyed for all these years and for whom I feel undiminished esteem. If I have opposed his classification of the butterflies, I have used, in my efforts to subvert it, the same weapons employed by him to defend it. I am anxious to say a thankful word to Mr. W. H. Edwards for his letters and the information he has given me and all of us on the North American butterflies. With Dr. Packard, I am one of four authors who, commencing to write at about the same time on American Lepidoptera before the war, have lived until to-day to see much that they have accomplished adopted, and, in a varying degree, also disputed. It must be our reward to have worked for the spread of knowledge according to our differing lights—*manifesta rotæ vestigia cernes*.

I am glad again to thank Mr. W. F. Kirby, of the British Museum (Natural History), for his complaisance in affording me information not to be found in Mr. Scudder's book. Mr. Quail's papers on the neururation have been suggestive to me. I am indebted to Dr. Chapman for letters and copies of his ingenious papers on the pupæ of butterflies. Finally I am indebted to Dr. O. Staudinger and A. Bang Haas for determinations which give this work an element of certainty as to the identity of material which it could not have had from my own authority.

EXPLANATION OF PLATE I.

The figures are obtained by an improved photo-lithographic process. *S* = subcostal vein; *R* = radius 1 to 5; *M* = media 1 to 3; *C* = cubitus 1 to 2; *A* = anal 1 to 3. The costal veins are absent in the Lepidoptera through reduction. The fork at base of second anal of primaries is not numbered. The first anal is usually obsolete. On hind wings h. s. = humeral spur.

Fig. 1. *Azalais gigantea*. Type of genus. This immaculate and more specialized form differs from *Leptidia* by the production of the primary wing between *M*1 and 2. On hind wings the position of *M*1 is further removed outwardly and *M*2 is nearer 3; the humeral spur is also straight and truncate.

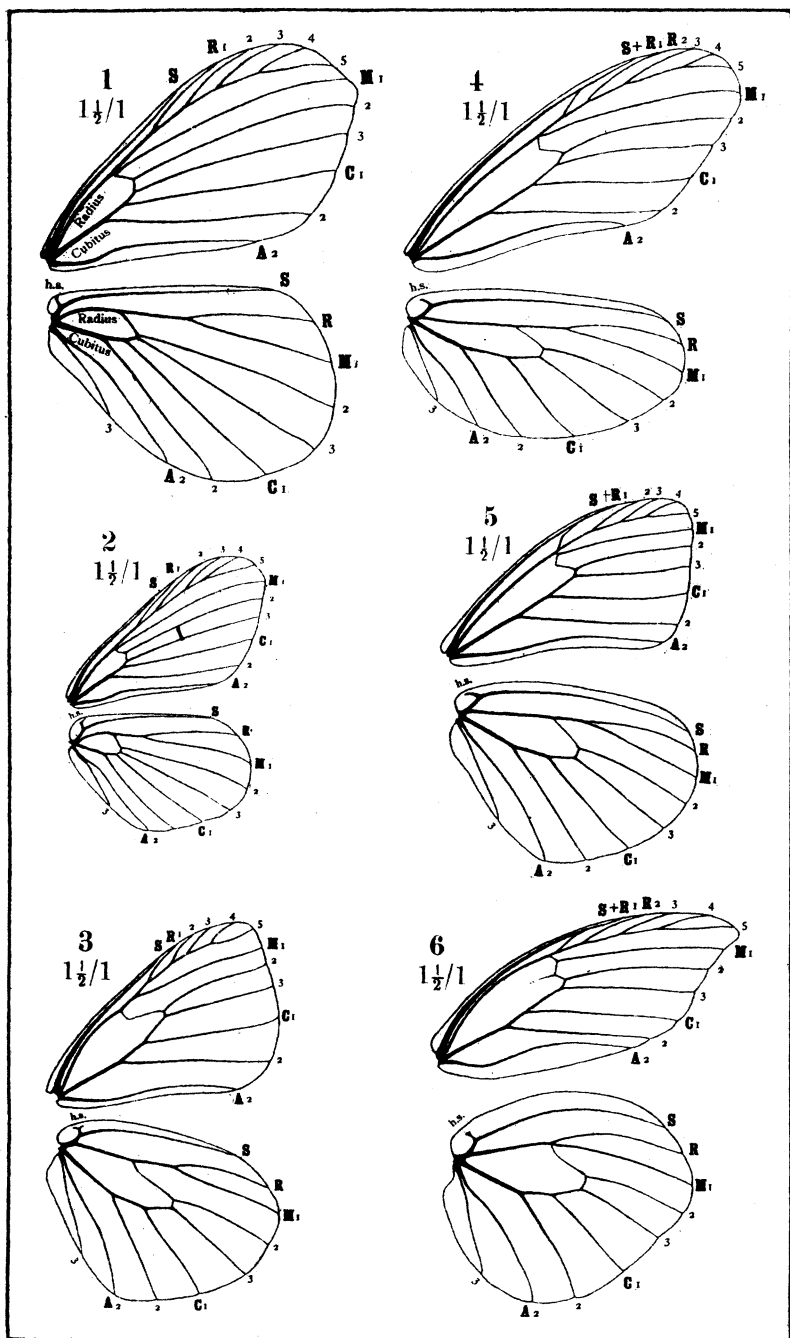
Fig. 2. *Leptidia sinapis*. Type of genus and subfamily. This latter is characterized, as compared with the Dismorphianæ, by the retreating discal cells and central position of second median on primaries. No trace of fork to second anal. Compare with preceding figure.

Fig. 3. *Pseudopieris nehemia* ♀. Type of genus. An isolated and specialized form belonging to the Dismorphianæ, which have proportionate discal cells and second median vein cubital on both wings. In *Pseudopieris* the cell retreats in its upper part, leaving the first median on primaries free from radius. The first radial is free to costa; h. s. Y-shaped. The uniformly pale color here accompanies a peculiar specialization in the veining.

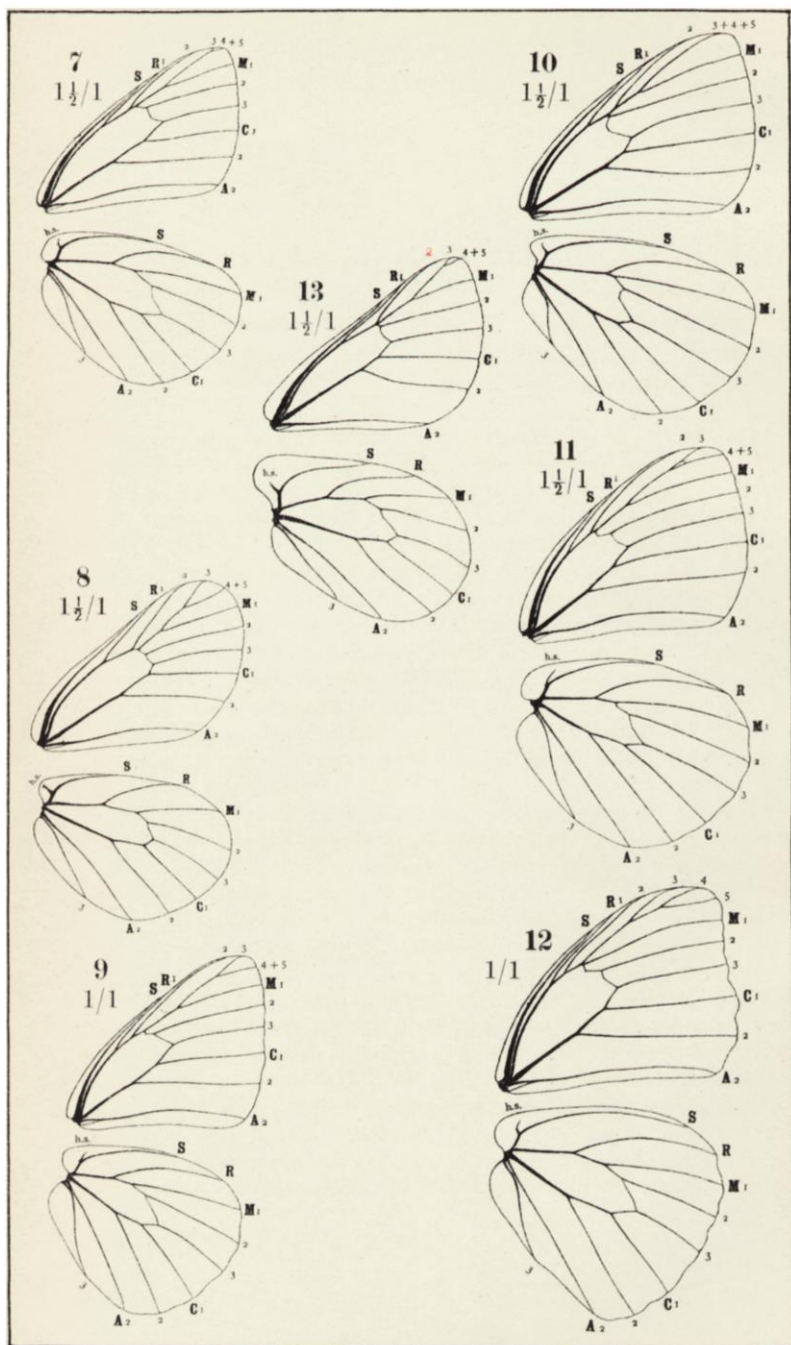
Fig. 4. *Leptalis astynome* ♀. Type of genus. The first radial fuses with subcostal; first median from radius at upper corner of discal cell. On hind wings *M*1 from radius well beyond discal cell.

Fig. 5. *Enantia melite* ♀. Type of genus. The first radial branch is bent and fused with subcostal. *M*1 from cross-vein close to upper corner of discal cell, hence more generalized than *Leptalis*.

Fig. 6. *Acmepteron nemesis* ♂. Type of genus. The proportions of the wings are Orthopteralike. The backward spur on discal cell, a relic of the base of media, marks the generalization. *R*1 straight, fusing with subcostal. *M*1 from cross-vein, further removed from upper corner of cell than in *Enantia*, hence the more generalized form. Hind wings with discal cross-vein joining *M*1 at furcation with radius. This dark form has ancestral characters compared with the two preceding. The Leptidianæ belong to the fauna of the Old, the Dismorphianæ to that of the New World.



Photolith. F. H. Bödeker, Hildesheim.



Photolith. F. H. Bödeker, Hildesheim.

EXPLANATION OF PLATE II.

The figures are obtained by an improved photo-lithographic process. *S* = subcostal; *R* = radius 1 to 5; *M* = media 1 to 3; *C* = cubitus 1 to 2; *A* = anal 1 to 3. The first anal vein is obsolete; the thin fork to second anal is not numbered. On hind wings h. s. = humeral spur.

Fig. 7. *Pieris napi*. Note the Pierine and original position of *R*1 and 2 above the cell; though here *R*2 is advanced nearly to cross-vein, and in this is *P. napi* a slightly more specialized form than the type of the genus *P. rapæ*, as also in that the fork *R*3 is still more reduced. On hind wings h. s. abbreviate, curving outwardly. The fork to second anal on fore wings is thin, but apparently a functional vein. Compare Schm. Hild. Taf. I, Fig. 5, for figure of *P. rapæ*.

Fig. 8. *Mesapia peloria*. Type of genus, belonging to the opaque-veined *Aporia* series. When compared with *Pieris*, more generalized, the fork of *R*3 being longer. Consult the figure of *Aporia*, cited in text, for comparative details.

Fig. 9. *Mylothris rhodope*. Type of genus; a four-branched form belonging to the *Ascia* series; *R*1 and *R*2 in the original Pierine position above the cell; the veinlet *R*3 is slightly bent just below costa (as in *Mancipium*), showing that an additional radial veinlet has shortly been given up.

Fig. 10. *Elodina egnatia* ♀. Type of genus; belongs to the clear-veined, thin and wide-winged *Ascia* group, convergent with *Pieris*. The most specialized form, as shown by the radius, being three-branched, and *R*2 advanced beyond cross-vein. Compare text.

Fig. 11. *Phrissura ægis* ♀. Type of genus; a more generalized form than *Elodina*, as shown by the four-branched radius; *R*2 not advanced as far as the cross-vein, still in the Pierine position. Compare, for these points, with preceding figure.

Fig. 12. *Nepheronia poppea (idotea)*. Type of genus. This is the generalized form of *Mylothris* (Fig. 9), and in which the radius is five-branched. *R*2 is further from cross-vein than in the more specialized *Mylothris*, of which this is probably the direct ancestral form. The shape of primaries is different from *Mylothris*, the pattern identical. The fork to second anal is here very thin and perhaps hardly functional.

Fig. 13. *Trifurcula huanco* ♂. The primary wing shows the *Trifurcula* position of *R*2, advanced to just opposite the cross-vein. Compare text.

EXPLANATION OF PLATE III.

The figures are obtained by an improved photographic process. S = subcostal vein; R = radius 1 to 5; M = media 1 to 3; C = cubitus 1 to 2; A = anal 1 to 3. On hind wings h. s. = humeral spur. The thin fork at base of second anal of primaries is not numbered. The costal vein is absent through reduction on both wings in the Lepidoptera.

Fig. 14. *Piccarda eucharis* ♀. Type of genus. A highly specialized Pierid, in which the radius of forewings is three-branched; R_2 has left the original Pierine position above the cell and traveled along radius until it forms but a moderate fork with $R_3 + 4 + 5$, before apex. M_1 has ascended the radius on its lower edge for a considerable distance beyond the cross-vein; hence this is the specialized form of the succeeding *Delias*. In both genera the fork to second anal of primaries is reduced to a mere scar.

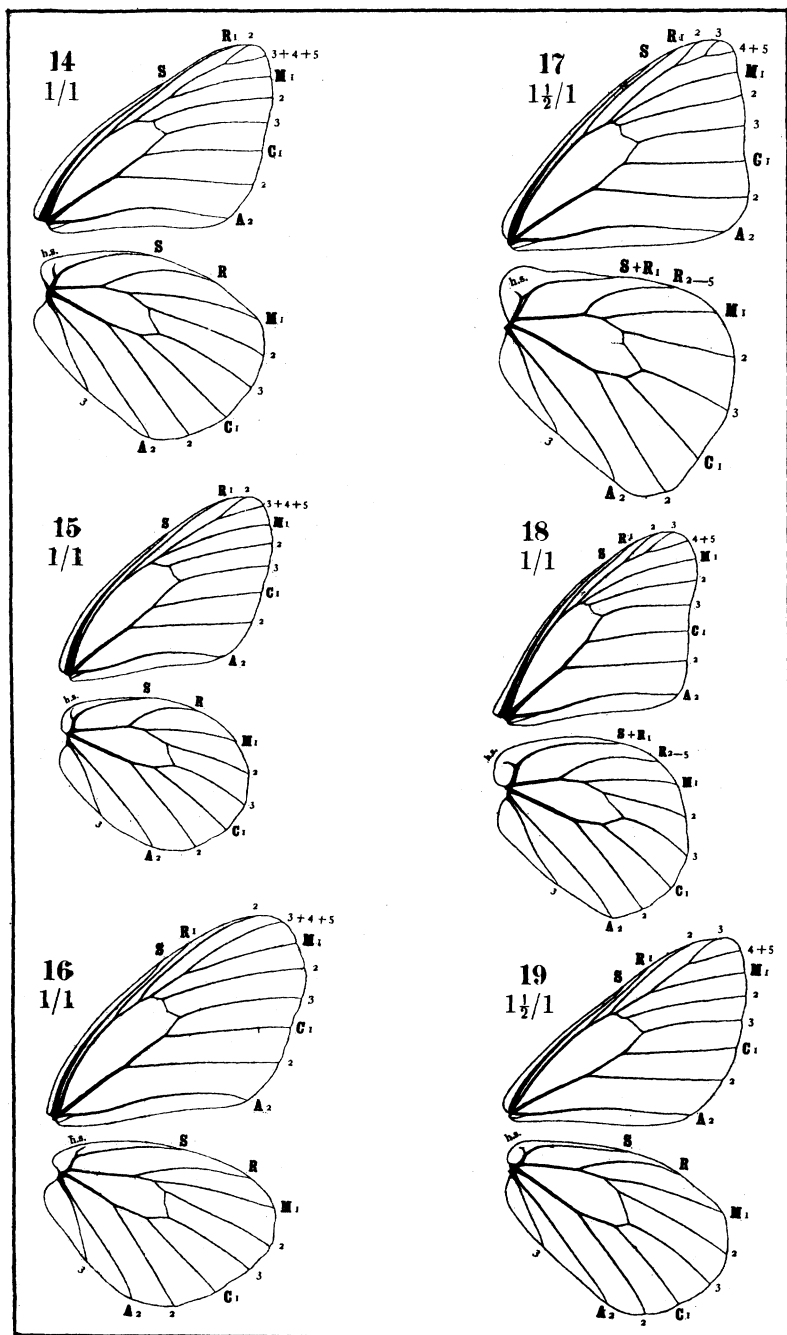
Fig. 15. *Delias egialea* ♀. Type of genus. Compare with *Piccarda* as to position of M_1 , which here leaves radius immediately beyond junction of cross-vein; fork of R_2 longer than in *Piccarda*. In these genera the specialization of radius has outstripped that of media, and reaches its fullest expression yet attained.

Fig. 16. *Pyrrhybris pyrrha* ♀. Type of genus. A specialized Pierid in which R_2 has retained the Pierine position above discal cell and has not traveled along radius. Hence this is more generalized than the preceding, although the radius is equally three-branched. Compare text.

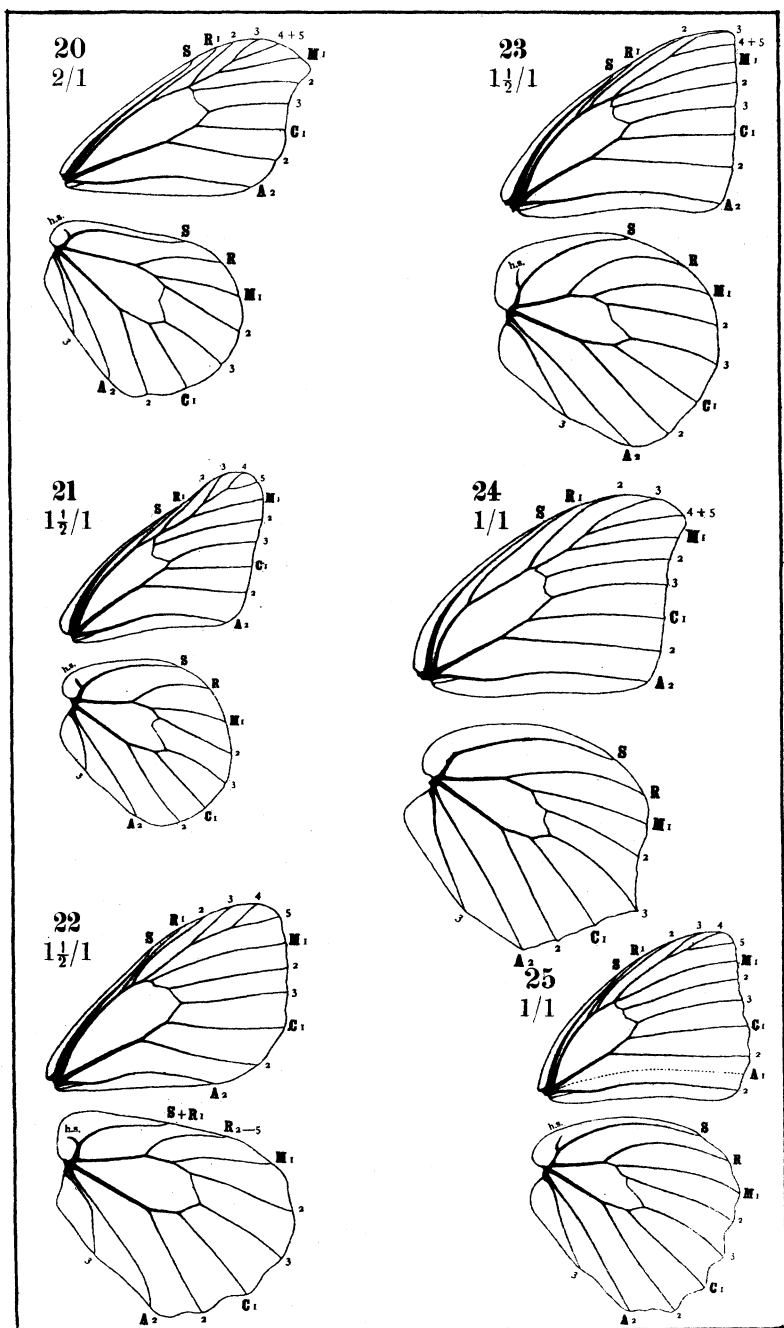
Fig. 17. *Hesperocharis erota*. Type of genus. Radius four-branched, the branches R_2 , R_3 , short, near together before apices, taking Anthocharid position; h. s. truncate.

Fig. 18. *Cunizza hirlanda*. Type of genus. Primaries with blunt and rounded apices, contrasting in shape with *Hesperocharis*. R_2 to 3 longer, and M_1 a little further from radius on crossvein, hence more generalized than *Hesperocharis*.

Fig. 19. *Neophasia menapia*. Type of genus. A typical Pierid in which R_2 keeps its original position above cell, but here well advanced. Radius four-branched. Probably a form ancestral to *Pyrrhybris*, or slightly divergent on the same line of specialization.



Photolith. F. H. Bödeker, Hildesheim.



Photolith. F. H. Bödeker, Hildesheim.

EXPLANATION OF PLATE IV.

The figures are obtained by an improved photographic process. *S* = subcostal vein; the costal vein is absent through reduction in the Lepidoptera; *R* = radius 1 to 5; *M* = media 1 to 3; *C* = cubitus 1 to 2; *A* = anal 1 to 3. On secondaries h. s. = humeral spur. The thin fork to second anal of primaries at base is not numbered.

Fig. 20. *Midea genutia*. Type of genus. A four-branched Anthocharid, in which *R*₂ has just passed out of the *Trifurcula* position opposite cross-vein. Compare with *Tetracharis*, in which *R*₂ has not reached the cross-vein.

Fig. 21. *Zegris eupheme*. Type of genus. A five-branched Anthocharid, in which *R*₂ has just passed the *Trifurcula* position. A more generalized form than *Midea*.

Fig. 22. *Eroessa chilensis*. Type of genus. One of the most generalized Pierids, ancestral to the Anthocharid line. Radius five-branched; *R*₂ in original position above the cell and close to *R*₁, which latter branchlet alone always remains constant in position and does not shift. The first median branchlet, which in all other Anthocharid genera has ascended radius and springs from it outside of cell, here retains its primitive position on cross-vein. This rare type is most instructive in supplying a generalized stage, rendering the succeeding steps of specialization in the position of the veins understandable. Compare these three figures with those of Anthocharid genera on Plate I, Vol. xxxvii, of these PROCEEDINGS.

Fig. 23. *Teracolus subfasciatus*. Type of genus. An African form more generalized than *Eurymus* (see PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, Vol. xxxvii, Pl. II, Fig. 8), with which it must be compared. It seems ancestral to *Eurymus*, in that *R*₂ has retained original position.

Fig. 24. *Amynthia mæcula*. Type of genus. This figure will serve to illustrate the wings of that line of the Eurymini in which the primaries have assumed a leaflike shape. Compare Schm. Hild. Taf. II, Fig. 8, for wings of its ally, *Colias rhamni*.

Fig. 25. *Eronia cleodora*. Type of genus. A generalized, radially five-branched form of the Euremini, which should be compared with *Eroessa* and *Nepheronia*. The resemblances suggest that these generalized types approach in wing structure. The five-branched types are rare in the Pierids, but in the brush-footed butterflies this generalized type of the radius is normal and never abandoned. In the primitive Pierid wing the radius was five-branched, and upon this character all the Hesperiades meet. The greatest divergence from this type is to be found in specialized Pierids, such as *Pontia* and *Piccarda*.